Missouri Department of Natural Resources

Biological Assessment Report

Little Lindley Creek
Dallas County, Missouri

2011 – 2012

Prepared for:

Missouri Department of Natural Resources
Division of Environmental Quality
Water Protection Program
Water Pollution Control Branch

Prepared by:

Missouri Department of Natural Resources
Division of Environmental Quality
Environmental Services Program
Water Quality Monitoring Section

Table of Contents

Tables

Figures

Attachments

1.0 Introduction

At the request of the Water Protection Program (**WPP**), the Environmental Services Program (**ESP**) Water Quality Monitoring Section (**WQMS**) conducted a biological assessment of Little Lindley Creek. Little Lindley Creek is a small tributary of Lindley Creek, located in the Ozark/Osage Ecological Drainage Unit (**EDU**) and originates near the town of Buffalo in southwest Missouri. The stream reach at water body identification number (**WBID**) 1438 is designated as Class C in the Missouri Water Quality Standards (MDNR 2012a) for 3.7 miles. This reach extends from just downstream of the Buffalo Wastewater Treatment Facility (**WWTF**) effluent discharge to the confluence with Lindley Creek (Figure 1). Designated uses for Little Lindley Creek are "warm water aquatic life protection, livestock and wildlife watering, and class B whole body contact" (MDNR 2012a). Little Lindley Creek was included on the 2002 303(d) list for biochemical oxygen demand (**BOD**) and the narrative criteria for volatile suspended solids (**VSS**) for 1 mile downstream of the effluent discharge from the Buffalo WWTF (NPDES permit number MO-0094854).

1.1 Study Area/Justification

The Little Lindley Creek watershed is primarily agricultural and contains one point source, the Buffalo WWTF (Figure 2). Visual surveys by the Missouri Department of Natural Resources (**MDNR**) on Little Lindley Creek downstream of the Buffalo WWTF were conducted in 1992, 1993, 1994, and 1997 (MDNR 2007). These surveys found that VSS in the form of sludge and algae was present on the stream bottom (narrative criteria for VSS). There were also numerous Buffalo WWTF permit violations from 1990 to 1998 for BOD and VSS. The Buffalo WWTF was upgraded in 2001, but results from a biological assessment study on Little Lindley Creek at two sampling stations in September 2002 and April 2003 indicated that the macroinvertebrate community was impaired (MDNR 2003). The biological assessment study also found that nitrogen and phosphorus concentrations were elevated at the sampling stations. In 2007 the permit for the Buffalo WWTF was modified to require the plant to construct improvements for sludge storage that will reduce the amount of sludge released into Little Lindley Creek. This study is a reassessment of the 2002-2003 biological assessment study that will examine the health of the macroinvertebrate community and water quality of Little Lindley Creek after the improvements to the Buffalo WWTF were made.

The Little Lindley Creek macroinvertebrate samples were assessed using two sets of criteria since Little Lindley Creek is much smaller than the reference stream segments used to determine the riffle/pool Ozark/Osage EDU biological criteria. The macroinvertebrate samples were first be compared to the Ozark/Osage EDU biological criteria for wadeable/perennial streams. The samples were then compared to candidate reference stream criteria. The streams used to calculate the candidate reference stream criteria include four streams (Barren Fork, Deer Creek, Macks Creek, and Starks Creek) that were sampled for the 2002-2003 biological assessment study, one stream (Dry Fork) that was sampled for the 2003-2004 Town Branch/Piper Creek biological assessment study (MDNR 2004), and Ingalls Creek, a control stream sampled for this study (Table

1). The Valley Segment Type (VST) 5 digit codes developed by the Missouri Resource Assessment Program (MORAP) were used in the selection of candidate reference stream segments for this study (Sowa et al. 2004). The candidate reference streams were chosen from a list of streams that had the same or a very similar five digit VST code to the Little Lindley Creek test stations and had little or no observable water quality problems in their watersheds. The four streams from the 2002-2003 Little Lindley Creek study included three candidate reference streams and the reference reach of Deer Creek, a biological criteria reference stream. The candidate reference stream sampled during the 2003-2004 Town Branch/Piper Creek study was Dry Fork and is located in Polk County. Ingalls Creek was identified as a candidate reference stream for the 2002-2003 study, but was not included in the report because it was only sampled during the spring 2003 sampling season. During the fall 2002 sampling season it was not sampled because drought conditions resulted in the stream having no water flowing over riffle habitat.

1.2 Objectives

1) Assess the biological (macroinvertebrate) integrity of Little Lindley Creek downstream of the Buffalo WWTF.

2) Assess the water quality of Little Lindley Creek downstream of the Buffalo WWTF.

1.3 Tasks

1) Conduct a biological assessment on Little Lindley Creek and Ingalls Creek.

2) Conduct a stream habitat assessment at the sampling stations to ensure comparability of aquatic habitats.

3) Collect water samples and water quality field measurements at the bioassessment sampling stations.

1.4 Null Hypotheses

1) The macroinvertebrate community will not differ between longitudinally separate reaches of Little Lindley Creek.

2) The macroinvertebrate assemblages in the Little Lindley Creek samples will be similar to the Ozark/Osage EDU wadeable/perennial stream biological criteria.

3) The macroinvertebrate assemblages in the Little Lindley Creek samples will be similar to the Ozark/Osage EDU candidate reference stream criteria.

4) Physicochemical water quality in Little Lindley Creek will meet the Water Quality Standards (**WQS**) of Missouri (MDNR 2012a).

5) Physicochemical water quality will not differ between longitudinally separate reaches of Little Lindley Creek.

Figure 1
Map of Little Lindley Creek and Sampling Stations

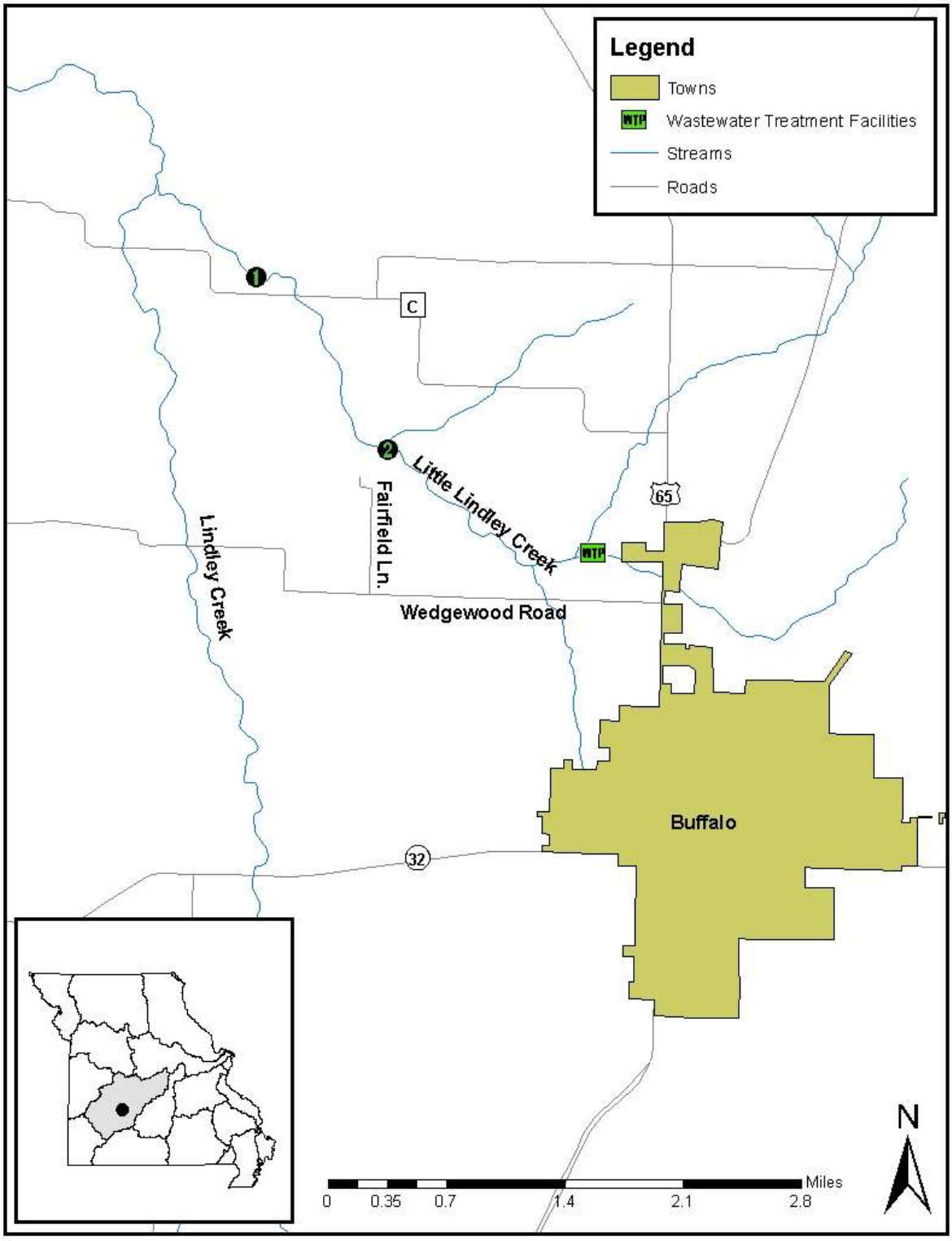


Figure 2
Land Use of the Little Lindley Creek Watershed

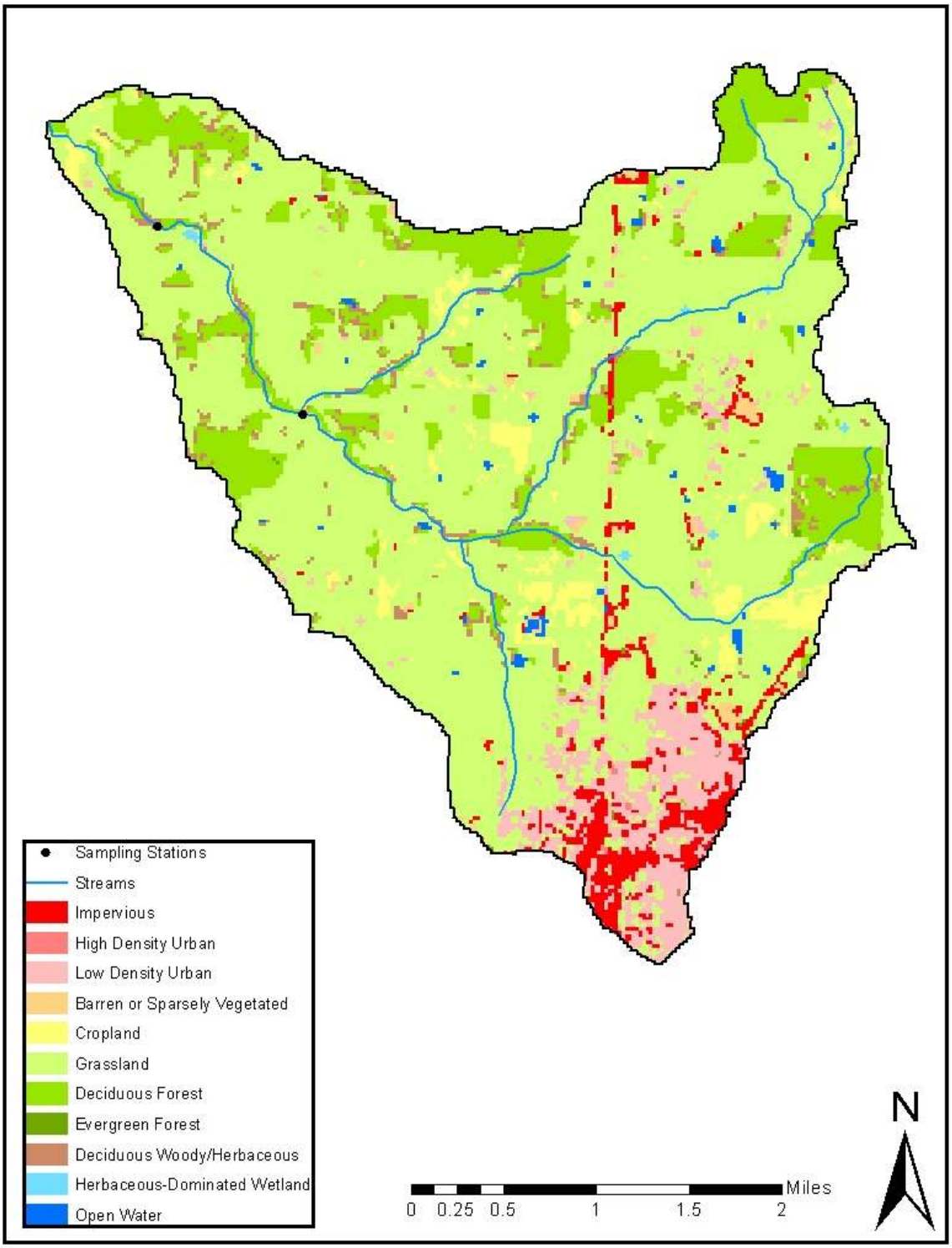


Table 1
Physical Characteristics of the Sampling Reaches for Little Lindley Creek and the Candidate Reference Streams Based on Values from the MoRAP Valley Segment Types (VST) Geographic Information Systems (GIS) Layer

	L. Lindley Creek #1	L. Lindley Creek #2	Ingalls Creek #1	Dry Fork #1	Starks Creek #1	Macks Creek #1	Barren Fork #1	Deer Creek #1
County	Dallas	Dallas	Hickory	Polk	Hickory	Camden	Miller	Benton
Watershed Area (mi^2)	11.9	9.6	27.4	30.1	35.1	33.7	27.6	63.3
Strahler Order	2	2	3	3	3	4	3	4
Link Magnitude	5	4	19	14	29	26	17	42
VST 5 Digit Code	22122	21121	22122	22122	22121	22122	22121	22121
Temperature Regime	Warm	Warm	Warm	Warm	Warm	Warm	Warm	Warm
Stream Size	Creek	Creek	Creek	Creek	Creek	Creek	Creek	Creek
Flow Regime	Permanent	Headwater	Permanent	Permanent	Permanent	Permanent	Permanent	Permanent
Geology	Limestone	Limestone	Limestone	Limestone	Limestone	Limestone	Limestone	Limestone
Relative Gradient	Medium	Low	Medium	Medium	Low	Medium	Low	Low

2.0 Methods

Carl Wakefield and Brandy Bergthold of the Biological Assessment Unit, WQMS, MDNR, Division of Environmental Quality, ESP conducted this study.

2.1 Study Timing

Macroinvertebrate and discrete water quality samples were collected during the fall 2011 and spring 2012 sampling seasons. Fall 2011 sampling was conducted on September 19-20, 2011, and spring 2012 sampling was conducted March 19, 2012.

2.2 Station Descriptions

The study area and sampling locations for the Little Lindley Creek bioassessment study are shown in Figures 1 and 3. A total of two Little Lindley Creek test stations and one Ingalls Creek candidate reference station were surveyed for bioassessment sampling and water quality. The locations of the two Little Lindley Creek sampling stations were very close to the locations that were sampled in the 2002-2003 study. Candidate reference data collected during the 2002-2003 Little Lindley Creek study, the 2003-2004 Town Branch/Piper Creek study, and Ingalls Creek candidate reference station were used to assess the Little Lindley Creek macroinvertebrate community.

2.2.1 Little Lindley Creek Bioassessment Sampling Stations

Little Lindley Creek #1 – Dallas County: Legal description was N ½ Sec. 8, T. 34 N., R. 20 W. Geographic coordinates were UTM zone 15, 0486994 Easting, 4171446 Northing. The station was located downstream of Highway C.

Little Lindley Creek #2 – Dallas County: Legal description was NE ¼, NW ¼ Sec. 16, T. 34 N., R. 20 W. Geographic coordinates were UTM zone 15, 0488249 Easting, 4169803 Northing. The station was located near Fairfield Lane.

2.2.2 Candidate Reference Bioassessment Sampling Stations

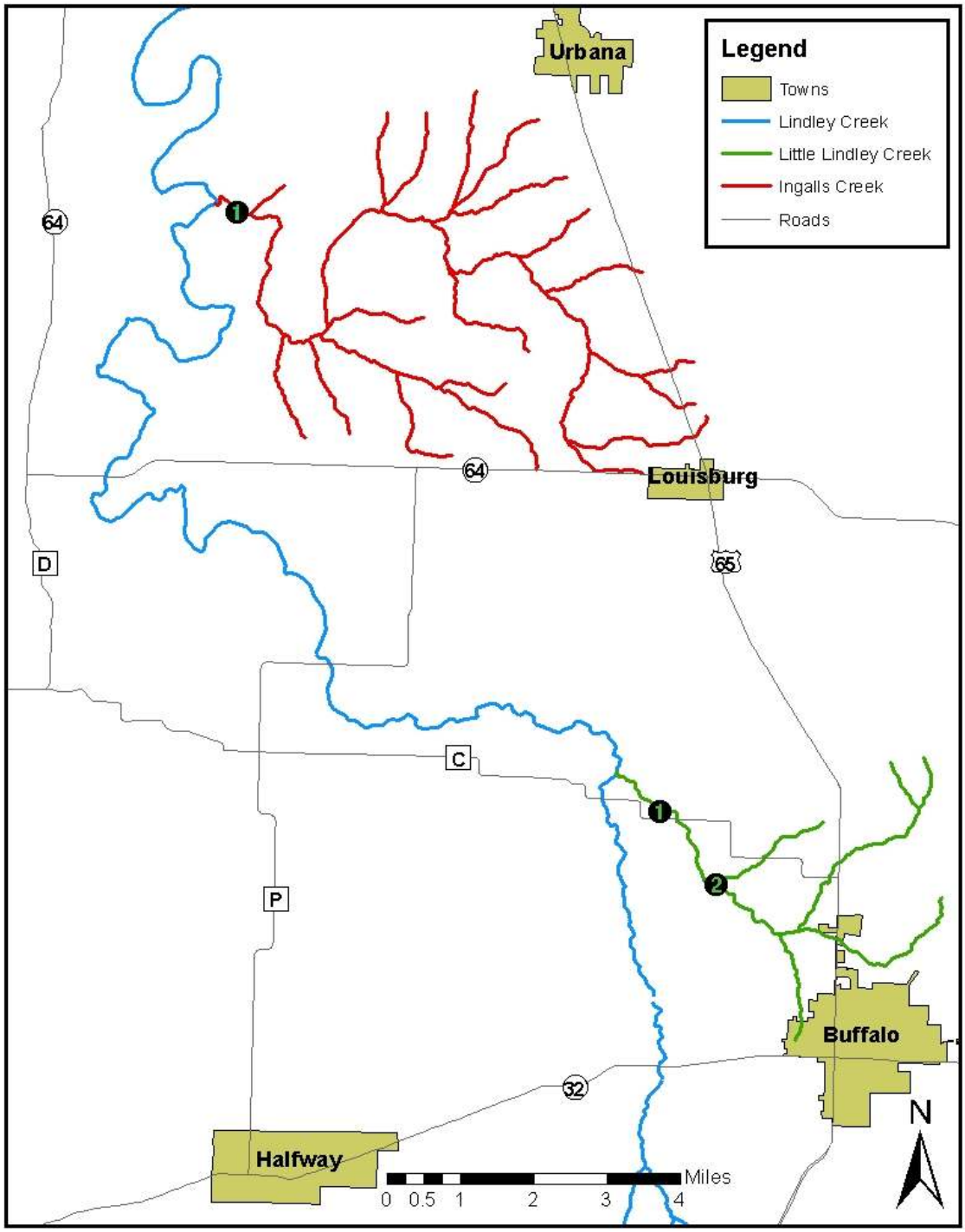
Barren Fork #1 – Miller County: Legal description was Sec. 16, T. 39 N., R. 13 W. Geographic coordinates were UTM zone 15, 0556263 Easting, 4218902 Northing.

Deer Creek #1 – Benton County: Legal description was NE ¼ Sec. 30, T. 40 N., R. 20 W. Geographic coordinates were UTM zone 15, 0485011, Easting, 4229279 Northing.

Dry Fork #1 – Polk County: Legal description was SW ¼ Sec. 35, T. 35 N., R. 23 W. Geographic coordinates were UTM zone 15, 0460915, Easting, 4177151 Northing.

Ingalls Creek #1 – Hickory County: Legal description was SE ¼, NW ¼ Sec. 4, T. 35 N., R. 21 W. Geographic coordinates were UTM zone 15, 0477728, Easting, 4184897 Northing.

Figure 3
Little Lindley Creek and Ingalls Creek Bioassessment Sampling Locations



Macks Creek #1 – Camden County: Legal description was Sec. 29, T. 38 N., R. 19 W. Geographic coordinates were UTM zone 15, 0496640 Easting, 4206301 Northing.

Starks Creek #1 – Hickory County: Legal description was Sec. 23, T. 38. N., R. 20 W. Geographic coordinates were UTM zone 15, 0491250 Easting, 4208246 Northing.

2.3 MoRAP Aquatic Ecological Classification

The aquatic ecological classification developed by the MoRAP is a classification system that divides the aquatic resources of Missouri into distinct regions. It has seven levels of classification starting at large regions and then dividing them into smaller sub-regions (Sowa et al. 2004). The following are the seven levels of classification in hierarchical order: zone, subzone, region, aquatic subregions, EDU, Aquatic Ecological Systems (**AES**), and VST. The levels of classification are based on biology, zoogeography, taxonomic composition, geology, soils, and groundwater connection. Some levels of the hierarchical system use geology and soils to classify whereas other levels use biology and taxonomic composition of aquatic communities. EDU and AES are the two levels of classification that will be assessed in detail for this study.

2.3.1 Ecological Drainage Unit

The EDU is level five of the classification hierarchy and is based on geographical variation of the taxonomic composition of the level four subregions. An EDU is a region in which aquatic biological communities and habitat conditions can be expected to be similar. Table 2 shows the land cover percentages from the Ozark/Osage EDU, the watersheds of the Little Lindley Creek test stations, and the watersheds of the candidate reference stations. Land cover data were derived from Thematic Mapper satellite data from 2000 to 2004. The land use at the Little Lindley Creek test stations was higher for percent impervious surface, low intensity urban, and grassland and lower for percent deciduous forest and deciduous woody/herbaceous than the candidate reference stations and the entire Ozark/Osage EDU.

2.3.2 Aquatic Ecological Systems

Aquatic Ecological Systems are level six of the classification hierarchy and classify aquatic systems based on geology, soils, landform, and groundwater influence. Little Lindley Creek is located in the Boeuf Creek AES type (Sowa and Diamond 2006). The Boeuf Creek AES type also includes two of the candidate reference streams, Ingalls Creek and Dry Fork. The Boeuf Creek AES type is primarily found on the outer edge of much of the core Ozarks. Local relief is variable and usually is between 50 to 200 feet. Bedrock geology is dominated by cherty dolomites with sandstone and limestone occasionally being present. Surface soil textures consist of silty loams or occasionally cherty loams that tend to have slow to moderate infiltration rates. Spring influence is variable and is not as characteristic as some of the other Ozark AES types. Historic vegetation consisted of oak savanna, woodlands, and smaller amounts of prairies and glades.

Table 2
Percent Land Cover

Land Cover	Ozark/Osage EDU	Ingalls Creek #1	Dry Fork #1	Starks Creek #1	Macks Creek #1	Barren Fork #1	Deer Creek #1	Little Lindley Creek #1	Little Lindley Creek #2
Impervious	1.2	0.7	1.5	0.4	1.2	0.4	0.5	3.7	4.6
High Intensity Urban	0	0.3	0	0	0.002	0	0	0.1	0.1
Low Intensity Urban	1.0	0.4	0.2	0.3	0.5	0.5	0.3	6.3	7.7
Barren/Sparsely Vegetated	0.5	0	0.4	0.2	0.9	0.5	0.4	1.0	1.2
Cropland	4.8	5.1	1.2	1.7	1.3	0.2	0.9	3.7	4.1
Grassland	43.0	53.2	46.3	41.6	38.4	50.1	35.2	67.7	66.7
Deciduous Forest	38.6	33.5	41.1	47.9	52.0	37.2	54.7	14.0	12.3
Evergreen Forest	1.4	0.5	1.2	0.7	0.1	4.1	0.3	0.1	0.1
Deciduous Woody/Herbaceous	4.8	5.4	7.5	5.9	5.1	6.0	5.7	2.8	2.1
Evergreen Woody/Herbaceous	0	0	0.2	0.1	0	0	0.1	0	0
Woody Dominated Wetland	0.7	0.2	0.02	0.8	0.01	0.6	1.3	0	0.2
Herbaceous-Dominated Wetland	0.2	0.04	0.001	0.01	0.1	0.03	0.03	0.1	0.04
Open Water	3.7	0.6	0.3	0.5	0.5	0.5	0.5	0.6	0.6

The other candidate reference reaches are located in the Tavern Creek AES type. Local relief is generally less than 200 feet, but surpasses that in some locations. The AES type consists of cherty dolomites and sandstones of the Gasconade and Roubidoux formations from the Ordovician period. Karst features are present and springs are numerous and some can be quite large. The surrounding land is heavily dissected and consists of steep slopes with rock outcroppings. Soil surface textures consist of cherty or silt loams soils with moderate to slow infiltration rates. Stream bed loads consist of gravel and sand and form bars made of the same material.

2.4 Stream Habitat Assessment

A standardized assessment procedure was followed as described for Riffle/Pool Habitat in the Stream Habitat Assessment Project Procedure (**SHAPP**) (MDNR 2012b). The habitat assessment was conducted at the two Little Lindley Creek test stations, the Ingalls Creek candidate reference station, and the Pomme de Terre River biological criteria reference station during September of 2011.

2.5 Biological Assessment

Biological assessments consist of macroinvertebrate collection and physicochemical sampling for two sample periods.

2.5.1 Macroinvertebrate Collection and Analysis

A standardized macroinvertebrate sample collection and analysis procedure was followed as described in the Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (**SMSBPP**) (MDNR 2012c) for riffle/pool (**RP**) streams. Three standard habitats— flowing water over coarse substrate (**CS**), depositional substrate in non-flowing water (**NF**), and rootmat (**RM**)—were collected at the sampling stations.

Macroinvertebrate data were analyzed using three methods. The first analysis was to calculate the Macroinvertebrate Stream Condition Index (**MSCI**) using the biological criteria for perennial/wadeable streams from the Ozark/Osage EDU using the four general biological metrics found in the SMSBPP (MDNR 2012c; MDNR 2002). The four general biological metrics used and found in the SMSBPP are: 1) Taxa Richness (**TR**); 2) Ephemeroptera/Plecoptera/Trichoptera Taxa (**EPTT**); 3) Biotic Index (**BI**); and 4) Shannon Diversity Index (**SDI**).

The second analysis was calculating MSCI scores using macroinvertebrate data collected at the candidate reference streams from the Ozark/Osage EDU using the same four metrics listed above. This analysis was conducted to determine the extent to which stream size affected the Little Lindley Creek macroinvertebrate community since the test stations were much smaller than the wadeable/perennial biological criteria reference streams used to calculate biological criteria for the Ozark/Osage EDU.

The third analysis was an evaluation of macroinvertebrate community composition by percent composition of EPT, sensitive taxa, functional feeding groups (FFG), functional

habitat groups (FHG), and dominant macroinvertebrate families and taxa. Comparisons of the macroinvertebrate community of Little Lindley Creek, the candidate reference streams, and the biocriteria reference streams were made.

2.6 Physicochemical Data Collection and Analysis

2.6.1 *In situ* Water Quality Measurements

During each sampling period, *in situ* water quality measurements were collected at each of the bioassessment sampling stations. Field measurements included water temperature (°C), dissolved oxygen (mg/L), conductivity (µS/cm), and pH.

2.6.2 Water Chemistry

Grab samples of stream water were collected and returned for analyses to ESP's Chemical Analysis Section. Samples from the bioassessment sampling stations were analyzed for total suspended solids, turbidity, chloride, total phosphorus, ammonia-N, nitrate+nitrite-N, and total nitrogen. Procedures outlined in Required/Recommended Containers, Volumes, Preservatives, Holding Times, and Special Sampling Considerations [Standard Operating Procedure (**SOP**) MDNR-ESP-001 (MDNR 2011)] and Field Sheet and Chain-of-Custody Record [SOP MDNR-ESP-002 (MDNR 2010a)] were followed when collecting water quality samples. Stream velocity was measured at each station during the survey period using a SonTek/YSI FlowTracker Handheld-ADV (Acoustic Doppler Velocimeter). Discharge was calculated per the methods in SOP MDNR-ESP-113, Flow Measurement in Open Channels (MDNR 2010b).

2.7 Data Analysis and Quality Control

The physicochemical data were examined by analyte to determine whether stations had violations of the Missouri WQS (MDNR 2012a). Sampling stations that had values not in compliance with the WQS or recommend U.S. Environmental Protection Agency (U.S. EPA) recommended reference values will be discussed with possible influences being identified.

3.0 Results

3.1 Stream Habitat Assessment

Table 3 provides habitat assessment scores for the Little Lindley Creek test stations, the Ingalls Creek candidate reference station, and the Pomme de Terre River biological criteria reference station. Stream habitat data were collected in September of 2011 with Carl Wakefield and Brandy Bergthold performing the scoring. SHAPP guidance states that test stations scoring at least 75 percent of the total score of reference station should support a similar biological community. The stream habitat total scores indicated that the Little Lindley Creek test stations should support a similar macroinvertebrate community since the scores were greater than 75 percent of the Pomme de Terre River habitat score. Little Lindley Creek test station #1 scored fairly well on most of the metrics except for bank vegetative protection and riparian zone width for the left bank. Little Lindley test station #2 scored a little lower than test station #1 with lower scores for epifaunal substrate and riffle quality. These two parameter scores were lower because bedrock

made up a large portion of the substrate within the sample reach. For the other habitat parameters, test station #2 scored fairly similar to test station #1 with low scores for bank vegetative protection and riparian zone width for the left bank.

Table 3
Predominant Category Habitat Values, Category Habitat Scores, and Total Habitat Scores from Stream Habitat Assessments for the Little Lindley Creek Test Stations, the Ingalls Creek Candidate Reference Station, and the Pomme De Terre River Biological Criteria Reference Station

Stream Habitat Parameters	Little Lindley Creek #1	Little Lindley Creek #2	Ingalls Creek #1	Pomme de Terre River #1
Stream Habitat Assessment Date	09/20/2011	09/19/2011	09/19/2011	09/20/2011
Epifaunal Substrate/Available Cover	II (13)	III (6)	II (13)	III (8)
Embeddedness	I (16)	I (17)	1 (16)	II (13)
Velocity/Depth Regime	II (12)	II (11)	III (10)	II (15)
Sediment Deposition	II (11)	II (15)	II (11)	IV (4)
Channel Flow Status	II (13)	II (12)	III (7)	II (13)
Channel Alteration	I (20)	I (20)	I (20)	I (20)
Riffle Quality	I (16)	III (10)	III (7)	III (10)
Bank Stability – Left Bank	I (10)	I (10)	I (10)	III (4)
Bank Stability – Right Bank	I (9)	I (10)	I (9)	IV (2)
Vegetative Protection – Left Bank	IV (1)	IV (2)	IV (0)	IV (1)
Vegetative Protection – Right Bank	IV (1)	IV (2)	IV (0)	IV (0)
Riparian Zone Width – Left Bank	I (9)	III (4)	I (10)	IV (2)
Riparian Zone Width – Right Bank	IV (2)	II (6)	I (9)	IV (2)
Total Habitat Score (% of BioRef)	**133 (141)**	**125 (132)**	**122 (129)**	**94 (100)**

Habitat parameter categories range from I to IV with category I = optimal, category II = suboptimal, category III = marginal, and category IV = poor. Habitat parameter scores are listed in parentheses and range from 0 to 20 except for vegetative protection and riparian zone categories which range from 0 to 10.

3.2 Macroinvertebrate Biological Assessment

3.2.1 Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (SMSBPP)

Ozark/Osage Biological Criteria Reference Stream Scoring

MSCI score was calculated for Little Lindley Creek test stations using the riffle/pool perennial/wadeable biological criteria for the Ozark/Osage EDU (Tables 4 and 5). Little Lindley Creek test stations and the Ingalls Creek candidate reference stream had fully supporting MSCI scores of 16 during the fall 2011 sampling season. During the spring 2012 sampling season, the Little Lindley Creek test stations had partially supporting MSCI scores of 12 at station #1 and 10 at station #2. Ingalls Creek #1 had a fully supporting score of 18 during the spring 2012 sampling season.

Each of the study stations had at least one biological metric that was lower than the optimum biological criteria reference range calculated for the Ozark/Osage EDU in both sample seasons. During the fall 2011 sample season, TR and EPTT were suboptimal at

both Little Lindley Creek stations and TR and SDI were suboptimal at Ingalls Creek. For the spring 2012 sample season, all but BI was suboptimal at Little Lindley #1 and all metrics were suboptimal at Little Lindley #2. All metrics except EPTT were in the optimal range at Ingalls Creek.

Candidate Reference Stream Criteria Scoring

Fall 2011 MSCI scores calculated using candidate reference biological criteria are shown in Table 4 and spring 2012 scores are presented in Table 5. Little Lindley Creek #1 had a fully supporting MSCI score of 18, Little Lindley Creek #2 had a partially supporting MSCI score of 14, and Ingalls Creek #1 had a partial supporting MSCI score of 12 during the fall 2011 sampling season. During the spring 2012 sampling season, Little Lindley Creek #1 had a partially supporting MSCI score of 14, Little Lindley Creek #2 had a partially supporting MSCI score of 10, and Ingalls Creek #1 had a fully supporting score of 18.

Each of the study stations had at least one biological metric value that was lower than the optimum range calculated using the candidate reference biological criteria in both sample seasons. During the fall 2011 sample season, the EPTT metric was suboptimal for Little Lindley Creek #1 and all the metrics except SDI were suboptimal for Little Lindley Creek #2. All of the metrics at Ingalls Creek were suboptimal. For the spring 2012 sample season, all metrics except biotic index were suboptimal at Little Lindley #1and all metrics were suboptimal at Little Lindley #2. The only metric that was suboptimal at Ingalls Creek was TR.

Table 4
Fall 2011 Riffle/Pool Ozark/Osage EDU Perennial/Wadeable and Candidate Reference Stream Biological Criteria, Biological Support Categories, and Macroinvertebrate Stream Condition Index (MSCI) Scores at the Little Lindley Creek Sampling Stations

Station	Sample No.	TR	EPTT	BI	SDI	MSCI	Support
Perennial/Wadeable Biological Criteria							
L. Lindley Creek #1	110983	79	12	5.9	3.34	16	F
L. Lindley Creek #2	110984	70	12	6.4	3.46	16	F
Ingalls Creek #1	110985	76	20	6.4	2.98	16	F
Metric Score=5	If	>84	>18	<6.7	>3.22	20-16	**F**ull
Metric Score=3	If	84-42	18-9	6.7-8.3	3.22-1.61	14-10	**P**artial
Metric Score=1	If	<42	<9	>8.3	<1.61	8-4	**N**on
Candidate Reference Stream Criteria							
L. Lindley Creek #1	110983	79	12	5.9	3.34	18	F
L. Lindley Creek #2	110984	70	12	6.4	3.46	14	P
Ingalls Creek #1	110985	76	20	6.4	2.98	12	P
Metric Score=5	If	>78	>20	<6.0	>3.06	20-16	**F**ull
Metric Score=3	If	78-39	20-10	6.0-8.0	3.06-1.53	14-10	**P**artial
Metric Score=1	If	<39	<10	>8.0	<1.53	8-4	**N**on

MSCI Scoring Table (in light gray) developed from BIOREF stream samples (n=26) for perennial/wadeable biological criteria and candidate reference stream criteria (n=6); TR=Taxa Richness; EPTT=Ephemeroptera, Plecoptera, Trichoptera Taxa; BI=Biotic Index; SDI=Shannon Diversity Index

Table 5
Spring 2012 Riffle/Pool Ozark/Osage EDU Perennial/Wadeable and Candidate Reference Stream Biological Criteria, Biological Support Categories, and Macroinvertebrate Stream Condition Index (MSCI) Scores at the Little Lindley Creek Sampling Stations

Station	Sample No.	TR	EPTT	BI	SDI	MSCI	Support
Perennial/Wadeable Biological Criteria							
L. Lindley Creek #1	120021	79	12	5.5	3.07	12	P
L. Lindley Creek #2	120022	63	8	6.5	2.71	10	P
Ingalls Creek #1	120023	91	25	5.3	3.29	18	F
Metric Score=5	If	>90	>25	<6.2	>3.16	20-16	**F**ull
Metric Score=3	If	90-45	25-13	6.2-8.1	3.16-1.58	14-10	**P**artial
Metric Score=1	If	<45	<13	>8.1	<1.58	8-4	**N**on
Candidate Reference Stream Criteria							
L. Lindley Creek #1	120021	79	12	5.5	3.07	14	P
L. Lindley Creek #2	120022	63	8	6.5	2.71	10	P
Ingalls Creek #1	120023	91	25	5.3	3.29	18	F
Metric Score=5	If	>94	>24	<5.9	>3.27	20-16	**F**ull
Metric Score=3	If	94-47	24-12	5.9-7.9	3.27-1.64	14-10	**P**artial
Metric Score=1	If	<47	<12	>7.9	<1.64	8-4	**N**on

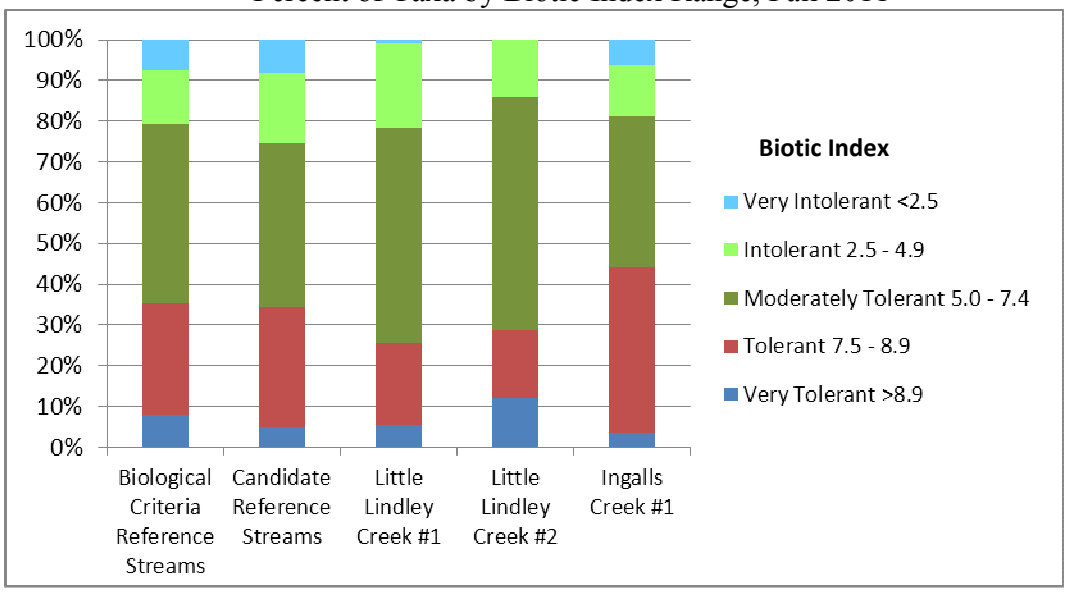
MSCI Scoring Table (in light gray) developed from BIOREF stream samples (n=36) for perennial/wadeable biological criteria and candidate reference stream criteria (n=7); TR=Taxa Richness; EPTT=Ephemeroptera, Plecoptera, Trichoptera Taxa; BI=Biotic Index; SDI=Shannon Diversity Index

3.2.2 Macroinvertebrate Percent and Community Composition

The percent composition of sensitive taxa, FFG, FHG, EPTT, and the five dominant macroinvertebrate families and taxa at each station are presented in Figures 4 through 9 and Tables 6 through 9. Values in bold type represent the five dominant macroinvertebrate families and taxa for each station.

Taxa in the moderately tolerant biotic index range made up about half of the organisms found in the Little Lindley Creek samples during the fall 2011 sampling season, which was much higher than the Ozark/Osage EDU biocriteria reference data, candidate reference stream data, and the Ingalls Creek candidate reference sample (Figure 4 and Table 6). The percent of the Little Lindley Creek samples made up of taxa in the tolerant range was lower than both reference datasets and much lower than the Ingalls Creek sample. The percent of taxa in the very tolerant range at Little Lindley Creek #2 was much higher than the Ingalls Creek station and the candidate reference stream data and a little higher than the biocriteria reference data. At Little Lindley Creek #1, the percent of taxa in the very tolerant range was a little higher than the Ingalls Creek station and the candidate reference data and a little lower than the biocriteria reference data. The percent taxa in the intolerant range was higher at Little Lindley Creek #1 than both reference datasets and Ingalls Creek. At Little Lindley Creek #2, the percent of taxa in the intolerant range was lower than the candidate reference stream data and a little higher than biocriteria reference data and Ingalls Creek. Taxa in the very intolerant range were much lower at the Little Lindley Creek test stations than both reference datasets and the Ingalls Creek station.

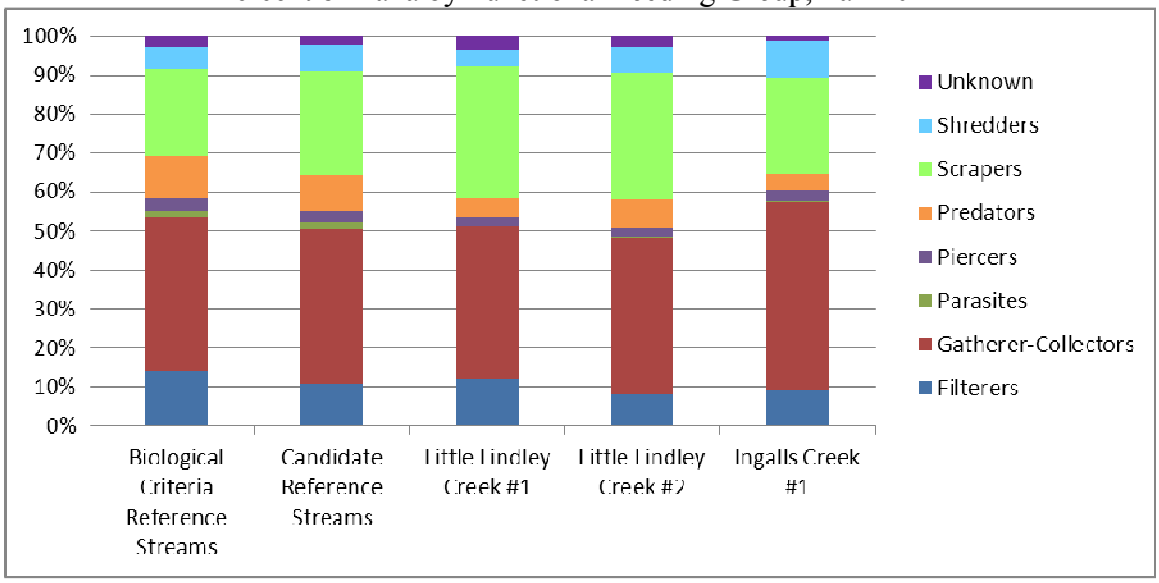
Figure 4
Percent of Taxa by Biotic Index Range, Fall 2011



Gatherer-collectors and scrapers were the two most abundant FFGs at the Little Lindley Creek test stations during the fall 2011 sampling season (Figure 5 and Table 6). The percent of the Little Lindley Creek samples made of gatherer-collectors was similar to biocriteria reference and candidate reference data and slightly lower than the Ingalls Creek candidate reference station. Percent scrapers at the Little Lindley Creek test stations were higher than both reference datasets and the Ingalls Creek station. Filterers made up about 12 percent of the sample at Little Lindley Creek #1 and 8 percent at Little

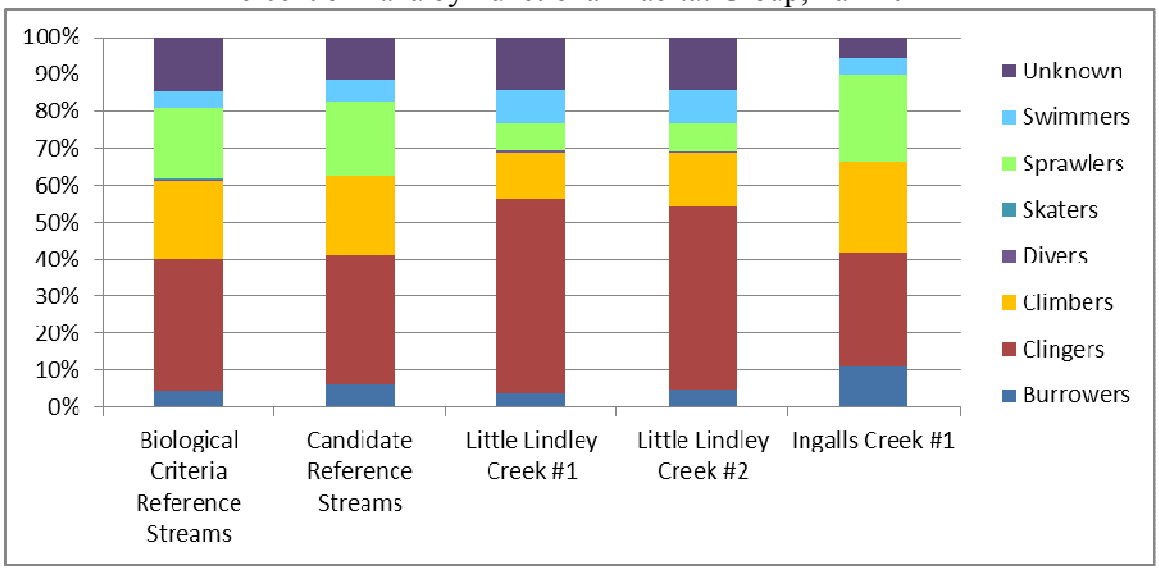
Lindley Creek #2, which was a little lower than biocriteria reference data. The filterer value was a little higher at Little Lindley Creek #1 and Little Lindley Creek was a little lower than the candidate reference data and Ingalls Creek station. Predators at the Little Lindley Creek test stations were lower in abundance than biological criteria and candidate reference data, but slightly higher than the Ingalls Creek station. Shredders made up about 4 percent of the sample at Little Lindley Creek #1 and 6 percent at Little Lindley Creek #2. Each of these values was lower than the candidate reference data and the Ingalls Creek station. Compared to biocriteria reference data, shredders were slightly less abundant at Little Lindley Creek #1, but more abundant at Little Lindley Creek #2.

Figure 5
Percent of Taxa by Functional Feeding Group, Fall 2011



During the fall 2011 sampling season clingers were the most abundant FHG and made up about 50 percent of the Little Lindley Creek samples (Figure 6 and Table 5). Clingers made up a much higher percentage of samples at the Little Lindley Creek test stations than the biocriteria reference data, candidate reference data, and the Ingalls Creek candidate reference station. Climbers were the second most abundant FHG in Little Lindley Creek, making up about 12 percent at test station #1 and about 15 percent at test station #2. These climber percentages were lower than both reference datasets and the Ingalls Creek station. Swimmers were the third most abundant FHG in Little Lindley Creek, making up about 9 percent of the sample at both test stations. The Little Lindley Creek swimmer percentages were higher than the other sampling stations. Sprawlers made up about 7 to 8 percent of the Little Lindley Creek samples and were much lower than both reference datasets and the Ingalls Creek station. Burrowers made up about 4 to 5 percent of the Little Lindley Creek samples, which was similar to biocriteria reference data but lower than the candidate reference streams and the Ingalls Creek station.

Figure 6
Percent of Taxa by Functional Habitat Group, Fall 2011



During the fall 2011 sampling season, percent EPTT and percent Ephemeroptera was lower at the Little Lindley test stations than the biological criteria data, the candidate reference data, and the Ingalls Creek candidate reference station (Table 7). Plecoptera was not present in Little Lindley Creek samples, but Trichoptera was fairly abundant. Trichoptera made up about 14 percent of the sample at Little Lindley Creek #1 and 6 percent at Little Lindley Creek #2.

Chironomidae was one of the most abundant families in the Little Lindley Creek test stations, making up about 13 percent of the sample at test station #1 and about 24 percent at test station #2 (Table 7). But none of the most abundant taxa in the Little Lindley Creek samples were chironomids. The most abundant chironomid in Little Lindley Creek #1 was *Stictochironomus*, which made up 2.3 percent of the sample and the most abundant chironomid in Little Lindley Creek #2 was *Polypedilum convictum*, which made up 4.8 percent of the sample. The most abundant taxon at the Little Lindley Creek test stations was the riffle beetle *Stenelmis*, making up about 12 percent of the samples (Table 6). The water penny *Psephenus herricki* and the baetid mayfly *Baetis* were abundant at both Little Lindley Creek test stations. Other taxa that were common were the hydropsychid caddisfly *Cheumatopsyche* and Planariidae at Little Lindley Creek #1; tubificid worms and the water penny *Ectopria nervosa* were common at Little Lindley Creek #2. The Ingalls Creek candidate reference sample had a much different macroinvertebrate community structure than Little Lindley Creek. The caenid mayfly *Caenis latipennis* made up almost 25 percent followed by the chironomid *Cricotopus/Orthocladius* group, which made up 11 percent of the sample. Other common Ingalls Creek taxa included the chironomid *Tanytarsus*, the baetid mayfly *Acerpenna*, and the leptophlebiid mayfly *Choroterpes*. The most abundant taxa collected from biocriteria reference streams were the caenid mayfly *Caenis latipennis*, the

leptohyphid mayfly *Tricorythodes*, the amphipod *Hyalella azteca*, the Tanytarsini chironomid *Tanytarsus*, and the hydropsychid caddisfly *Cheumatopsyche*. Most of the taxa that were common in the biocriteria reference streams also were common in the candidate reference streams. The most abundant taxa found in the candidate reference streams were *C. latipennis*, *H. azteca, Tanytarsus*, *Cheumatopsyche*, *Stenelmis*, and *P. herricki*.

Table 6
Biological Metric Values for Sensitive Taxa, Functional Feeding Groups (FFG), and Functional Habitat Groups (FHG) at the Little Lindley Creek Test Stations, the Ingalls Creek Candidate Reference Station, Biological Criteria Reference Samples, and Candidate Reference Samples, Fall 2011

Variable-Station	Biocriteria Reference Data	Candidate Reference Data	Little Lindley Creek #1	Little Lindley Creek #2	Ingalls Creek #1
Sample Number			110983	110984	110985
Sensitive Taxa					
% Biotic Index >9.0	8.1	4.8	5.6	11.9	3.7
% Biotic Index 7.5-9.0	27.2	29.4	19.9	16.7	40.4
% Biotic Index 5.0-7.5	43.9	40.3	52.8	57.2	37.2
% Biotic Index 2.5-5.0	13.3	17.4	20.8	14.2	12.6
% Biotic Index <2.5	7.5	8.0	1.0		6.1
FFG Metrics					
% Filterers	14.1	10.7	12.1	8.0	8.9
% Gatherer-Collectors	39.3	39.6	39.1	40.4	48.4
% Parasites	2.0	1.8	0.1	0.2	0.3
% Piercers	2.8	2.9	2.0	2.0	2.8
% Predators	11.0	9.4	4.9	7.5	4.2
% Scrapers	22.4	26.5	34.1	32.7	24.5
% Shredders	5.4	6.9	4.2	6.2	9.8
FHG Metrics					
% Burrowers	4.4	6.2	3.7	4.9	10.8
% Clingers	35.8	35.1	52.8	49.1	31.2
% Climbers	21.0	21.0	12.2	14.9	24.4
% Divers	0.4	0.2	0.6	0.3	0.2
% Skaters	0.1	0.1	0.2		
% Sprawlers	19.0	20.1	7.2	7.6	23.0
% Swimmers	4.7	5.7	9.0	8.8	4.7

Biocriteria and candidate reference stream data values are average percent

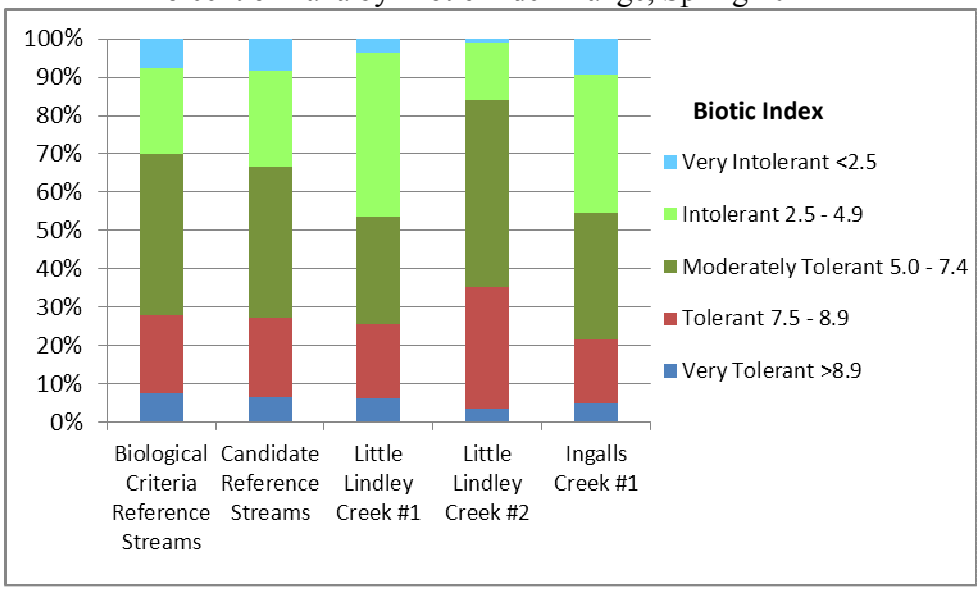
Table 7
Percent EPT, Dominant Macroinvertebrate Families, and Taxa at the Little Lindley Creek Test Stations, the Ingalls Creek Candidate Reference Station, Biological Criteria Reference Samples, and Candidate Reference Samples, Fall 2011

Variable-Station	Biotic Index	Biological Criteria Data	Candidate Reference Data	Little Lindley Creek #1	Little Lindley Creek #2	Ingalls Creek #1
EPT Metrics						
% EPT		42.8	39.0	33.4	23.9	43.0
% Ephemeroptera		34.9	32.3	19.5	17.4	42.1
% Plecoptera		0.7	0.3			0.5
% Trichoptera		6.8	6.4	13.9	6.0	0.3
Percent Dominant Families						
Chironomidae	8.0	**21.4**	**26.2**	**12.8**	**23.8**	**39.8**
Caenidae	7.0	**11.9**	**15.2**	1.6	1.0	**24.6**
Heptageniidae	4.0	**10.0**	**6.6**	6.2	5.8	**4.9**
Elmidae	4.0	**7.8**	**6.8**	**17.6**	**14.6**	3.8
Hyalellidae	*	**6.9**	5.6	1.0	1.5	3.3
Psephenidae	*	1.3	**5.8**	**11.9**	**11.8**	1.7
Baetidae	4.0	1.7	2.6	**9.6**	**10.5**	**7.1**
Hydropsychidae	4.0	3.6	3.0	**8.1**	4.5	0.1
Tubificidae	9.2	2.4	1.3	1.8	**6.2**	1.5
Leptophlebiidae	2.0	1.4	2.5	0.8		**5.2**
Percent Dominant Taxa						
Caenis latipennis	7.6	**7.1**	**12.5**	1.6	1.0	**24.5**
Tricorythodes	5.4	**7.0**	2.4	1.3	0.1	0.1
Hyalella azteca	7.9	**6.8**	**5.6**	1.0	1.5	3.3
Tanytarsus	6.7	**3.8**	**4.2**	1.3	2.6	**9.5**
Cheumatopsyche	6.6	**3.4**	**4.2**	**8.1**	4.5	0.1
Stenelmis	5.4	3.3	**4.4**	**12.4**	**11.8**	2.4
Psephenus herricki	2.5	1.1	**5.4**	**10.5**	**6.9**	1.6
Baetis	6.0	0.6	0.3	**9.5**	**9.8**	0.2
Planariidae	7.5	0.5	0.4	**5.1**	1.5	0.4
Tubificidae	9.2	2.0	1.0	1.3	**5.2**	1.5
Ectopria nervosa	4.3	0.1	0.4	1.4	**4.9**	0.1
Crictopus/Orthocladius Grp.	6.5	0.7	2.9		1.0	**11.0**
Acerpenna	3.7	0.3	1.8	0.1		**5.4**
Choroterpes	2.0	0.4	1.4	0.8		**5.2**

Biocriteria and candidate reference stream data values are average percent
*Biotic index values were not available for these taxa

The spring 2012 Little Lindley Creek #2 macroinvertebrate community was made up of more tolerant taxa than the other sampling stations (Figure 7 and Table 8). Taxa in the tolerant and moderately tolerant range made up a higher percent of the sample at Little Lindley Creek #2 than at Little Lindley Creek #1, the Ingalls Creek candidate reference station, and both reference datasets. Little Lindley Creek #2 did, however, have a smaller percentage of taxa in the very tolerant range (BI >9.0) than the other sampling stations. The percentage of the Little Lindley Creek #2 sample made up of taxa in the intolerant range (BI 2.5-5.0) and very intolerant range (BI <2.5) was much lower than the other sampling stations. The percent of the taxa at Little Lindley Creek #1 in the moderately tolerant range was much lower than both reference datasets and a little lower than the Ingalls Creek station. The percent of taxa in the tolerant range at Little Lindley Creek #1 was slightly lower than the reference datasets and a little higher than the Ingalls Creek station. For the very tolerant range, Little Lindley Creek #1 was a little higher than the Ingalls Creek station and a little lower than both reference datasets. The percent of the Little Lindley Creek #1 sample made up of taxa in the intolerant range was much higher than reference data and Ingalls Creek. For the very intolerant range, Little Lindley Creek #1 was much lower than the reference data and the Ingalls Creek station.

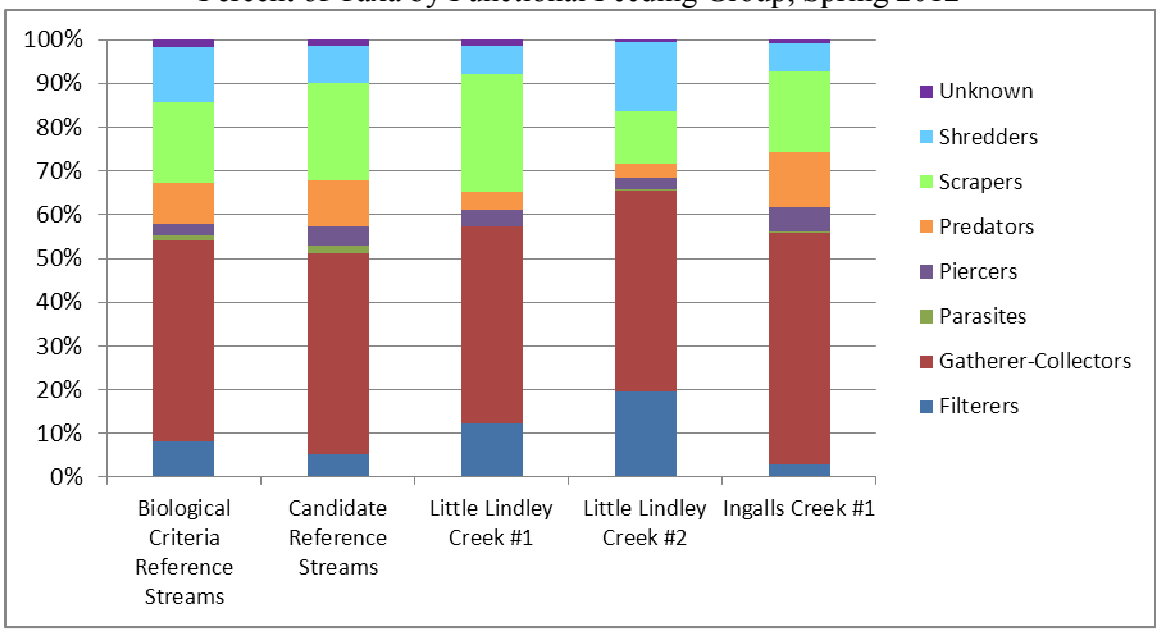
Figure 7
Percent of Taxa by Biotic Index Range, Spring 2012



Gatherer-collectors were the most abundant FFG at the Little Lindley Creek test stations during the spring 2012 sampling season (Figure 8 and Table 8). The percent of gatherer-collectors in the Little Lindley Creek samples was similar to biocriteria reference and the candidate reference data and slightly lower than the Ingalls Creek station. Scrapers were second in abundance at Little Lindley Creek #1 and were much more abundant than Little Lindley Creek #2, Ingalls Creek #1, and the biological criteria data. Slightly more

scrapers were present at Little Lindley Creek #1 than the candidate reference data. The percent of scrapers present at Little Lindley Creek #2 was not only lower than Little Lindley Creek #1, but also lower than both reference datasets and the Ingalls Creek station. Filterers were the second most abundant FFG at Little Lindley Creek #2 and made up a much higher percentage of the sample than both reference datasets and the Ingalls Creek station. Filterers did not make up as much of the sample at Little Lindley Creek #1, but were higher than the biocriteria streams, candidate streams, and the Ingalls Creek station. Shredders made up about 16 percent of the Little Lindley Creek #2 sample, which was slightly higher than biocriteria reference data and much higher than the candidate reference data and the Ingalls Creek station. At Little Lindley Creek #1, percent shredders were similar to the Ingalls Creek station, but were lower than both reference datasets. Predators, which made up about 4 percent of the Little Lindley Creek #1 sample and 3 percent at Little Lindley Creek #2, were much lower than the biocriteria reference streams, the candidate reference streams, and the Ingalls Creek station.

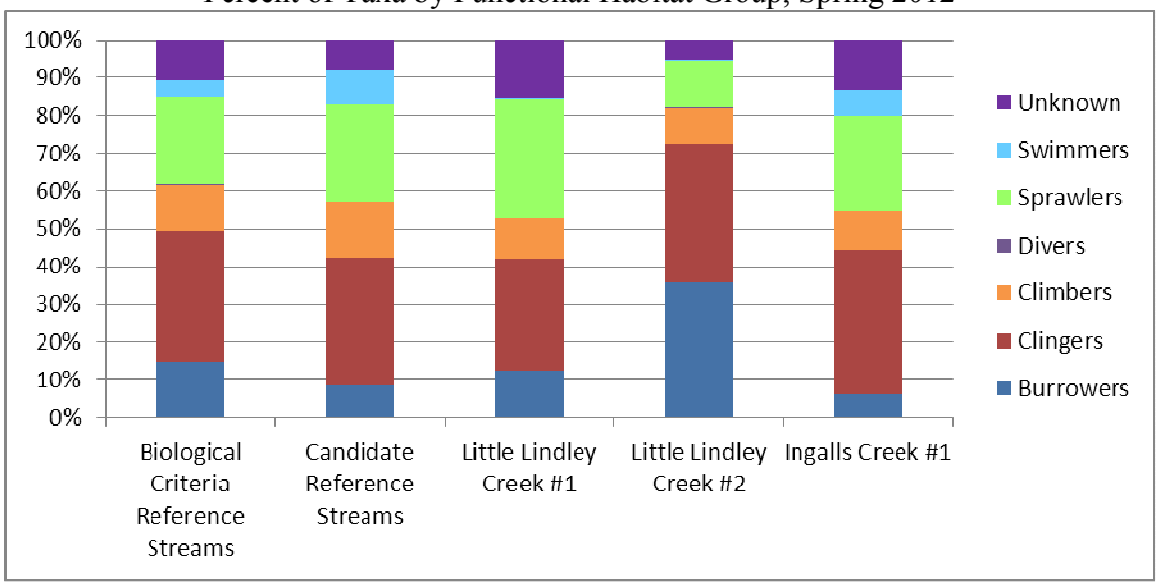
Figure 8
Percent of Taxa by Functional Feeding Group, Spring 2012



During the spring 2012 sampling season, clingers were one of the most abundant FHGs at the Little Lindley Creek test stations, making up about 29 percent at test station #1 and about 37 percent at test station #2 (Figure 9 and Table 8). Percent clingers at Little Lindley Creek #1 were slightly lower than the biocriteria reference data, the candidate reference data, and Ingalls Creek candidate reference station. At Little Lindley Creek #2, percent clingers were slightly higher than both reference datasets and slightly lower than the Ingalls Creek station. Sprawlers were the most abundant FHG at Little Lindley Creek #1, making up about 31 percent of the sample, which was higher than the biocriteria reference streams, the candidate reference streams, and the Ingalls Creek station.

Sprawlers made up about 12 percent of the Little Lindley Creek #2 sample and were much lower in abundance than both reference datasets and the Ingalls Creek station. Burrowers were abundant at Little Lindley Creek #2 and made up about 36 percent of the sample. This percentage was much higher than the other sampling stations. At Little Lindley Creek #1, burrowers made up about 13 percent of the sample, which was slightly lower than biocriteria reference data, but higher than the candidate reference data and the Ingalls Creek station. Climbers made up about 11 percent of the Little Lindley Creek #1 sample and about 9 percent at Little Lindley Creek #2. The percent climber values at the Little Lindley Creek test stations were similar to the Ingalls Creek station and a little lower than both reference datasets. Swimmers were very low in abundance at both Little Lindley Creek test stations and much lower than the biocritiera reference streams, the candidate reference streams, and the Ingalls Creek station.

Figure 9
Percent of Taxa by Functional Habitat Group, Spring 2012



Most of the spring 2012 EPT metrics were much lower at Little Lindley Creek stations than reference conditions and the Ingalls Creek candidate reference station (Table 9). Percent EPTT, percent Ephemeroptera, and percent Plecoptera were much lower in the Little Lindley Creek samples than the biocriteria reference streams, the candidate reference streams, and the Ingalls Creek station. Percent Trichoptera was fairly similar to biocriteria reference data and the Ingalls Creek station, but was lower than the candidate reference data.

Chironomidae was the most abundant family found in the spring 2012 Little Lindley Creek macroinvertebrate samples, making up about 59 percent of the sample at test station #1 and about 79 percent of the sample at test station #2 (Table 9). Percent Chironomidae was much more abundant at the Little Lindley Creek test stations than

both reference datasets and the Ingalls Creek candidate reference station. The most common chironomids in the Little Lindley Creek #1 sample were *Eukiefferiella*, which made up about 24 percent of the sample, *Dicrotendipes* (7.7 percent), and *Cricotopus/Orthocladius* group (3.5 percent). At Little Lindley Creek #2, the most common chironomids were *Dicrotendipes*, making up about 25 percent of the sample, *Cricotopus/Orthocladius* group (21 percent), *Eukiefferiella* (about 9 percent), and *Polypedilum convictum* (about 6 percent). Other taxa that were common in Little Lindley Creek samples were the black fly *Simulium* at test station #1, the elmid beetle *Stenelmis* at both test stations, and the pleurocerid snail *Elimia* at test station #1. Ingalls Creek had a very different macroinvertebrate community with a higher abundance of mayflies and stoneflies than Little Lindley Creek. Dominant taxa included the baetid mayfly *Acentrella*, which made up about 24 percent of the sample, the caenid mayfly *Caenis latipennis* (about 10 percent), heptageniid mayflies (about 6 percent), and the perlodid stonefly *Isoperla* (about 4 percent). Chironomids were also abundant in Ingalls Creek, making up about 36 percent of the sample. The most abundant chironomids in the Ingalls Creek sample were *Crictopus/Orthocladius* group and *Thienemannimyia* group. The macroinvertebrate community data from the biocriteria and the candidate reference streams showed that many of the same taxa were common in both stream size classes. Most of the abundant taxa in the biocriteria reference and the candidate reference streams were chironomids. Chironomids that were commonly found in both reference datasets were *Cricotopus/Orthocladius* group, *Tanytarsus,* and *Eukiefferiella*. Non-chironomid taxa that were common in the reference streams were *C. latipennis* in both stream size classes, the amphipod *Hyalella azteca* in the biocriteria reference streams, the baetid mayfly *Acentrella* in candidate reference streams, and the elmid beetle *Stenelmis* in the candidate reference streams.

Table 8
Biological Metric Values for Sensitive Taxa, Functional Feeding Groups (FFG), and Functional Habitat Groups (FHG) at the Little Lindley Creek Test Stations, the Ingalls Creek Candidate Reference Station, Biological Criteria Reference Samples, and Candidate Reference Samples, Spring 2012

Variable-Station	Biocriteria Reference Data	Candidate Reference Data	Little Lindley Creek #1	Little Lindley Creek #2	Ingalls Creek #1
Sample Number			120021	120022	120023
Sensitive Taxa					
% Biotic Index >9.0	7.7	6.5	6.2	3.5	5.0
% Biotic Index 7.5-9.0	20.3	20.8	19.3	31.6	16.5
% Biotic Index 5.0-7.5	42.2	39.4	28.1	48.9	33.2
% Biotic Index 2.5-5.0	22.1	25.0	42.9	15.1	36.1
% Biotic Index <2.5	7.8	8.4	3.6	0.9	9.2
FFG Metrics					
% Filterers	8.2	5.3	12.3	19.6	3.0
% Gatherer-Collectors	45.8	45.9	45.0	46.0	52.8
% Parasites	1.3	1.8	0.1	0.2	0.5
% Piercers	2.6	4.4	3.6	2.7	5.3
% Predators	9.4	10.6	4.2	3.1	12.7
% Scrapers	18.5	22.2	26.8	12.1	18.3
% Shredders	12.6	8.3	6.5	15.8	6.7
FHG Metrics					
% Burrowers	14.8	8.5	12.7	35.6	6.2
% Clingers	34.7	34.0	29.4	37.1	38.1
% Climbers	12.0	14.6	10.7	9.4	10.4
% Divers	0.2	0.2	0.1	0.2	0.2
% Sprawlers	23.4	25.7	31.4	12.1	25.0
% Swimmers	4.3	9.1	0.3	0.3	6.7

Biocriteria and candidate reference stream data values are average percent

Table 9
Percent EPT, Dominant Macroinvertebrate Families, and Taxa at the Little Lindley Creek Test Stations, the Ingalls Creek Regional Control Station, Biological Criteria Reference Samples, and Candidate Reference Samples, Spring 2012

Variable-Station	Biotic Index	Biological Criteria Data	Candidate Reference Data	Little Lindley Creek #1	Little Lindley Creek #2	Ingalls Creek #1
EPT Metrics						
% EPT		29.5	41.9	3.8	2.7	53.5
% Ephemeroptera		20.1	28.9	1.1	1.0	41.6
% Plecoptera		6.7	8.4	0.9	0.1	10.3
% Trichoptera		2.7	4.7	1.8	1.6	1.6
Percent Dominant Families						
Chironomidae	8.0	**46.7**	**36.4**	**58.7**	**78.5**	**35.6**
Caenidae	7.0	**8.0**	**11.0**	0.3		**10.1**
Hyalellidae	*	**4.7**	1.8	0.7		1.3
Heptageniidae	4.0	**4.7**	**4.7**	0.8	1.0	**5.8**
Perlidae	3.0	**3.4**	2.6	0.6	0.1	3.4
Baetidae	4.0	2.8	**8.6**			**25.3**
Simuliidae	6.0	1.7	0.8	**8.9**	**2.0**	1.5
Elmidae	4.0	3.3	**5.3**	**8.5**	**5.8**	2.6
Pleuroceridae	*	0.8	1.2	**6.0**		0.2
Planariidae	7.5	0.4	0.5	**3.9**	0.6	0.4
Psephenidae	*	0.6	0.8	1.0	**3.0**	0.6
Tubificidae	9.2	2.8	1.2	0.7	**2.2**	0.3
Perlodidae	2.0	1.3	2.6	0.1		**3.9**
Percent Dominant Taxa						
Cricotopus/Orthocladius Grp.	6.5	**14.4**	**7.6**	3.5	**20.7**	**5.0**
Caenis latipennis	7.6	**5.2**	**10.8**	0.3		**10.1**
Hyalella azteca	7.9	**4.6**	1.8	1.6		1.3
Eukiefferiella	4.0	**4.5**	**3.2**	**23.6**	**9.1**	3.4
Tanytarsus	6.7	**3.2**	**3.2**	1.6	3.6	2.4
Acentrella	4.0	2.1	**8.2**			**23.7**
Simulium	4.4	3.0	0.6	**8.9**	2.0	1.5
Stenelmis	5.4	2.5	**4.1**	**8.1**	**5.6**	2.4
Dicrotendipes	7.9	1.7	0.6	**7.7**	**25.4**	0.5
Elimia	2.5	0.7	1.2	**6.0**		0.2
Polypedilum convictum	5.3	1.4	0.9	0.7	**5.7**	1.2
Thienemannimyia Grp.	6.0	1.4	1.8	1.4	3.4	**4.2**
Isoperla	2.0	1.4	2.2	0.1		**3.9**

Biocriteria and candidate reference stream data values are average percent
*Biotic index values were not available for these taxa

3.3 Physicochemical Data

Water samples and field measurements were collected during the fall 2011 and spring 2012 macroinvertebrate sampling periods (Table 10). The results showed that no water quality standards were violated, but some parameters (nitrate +nitrite-N, total nitrogen, total phosphorus, and turbidity) currently are not in the water quality standards were elevated compared to United States Environmental Protection Agency (U.S. EPA)

recommended reference values for those parameters (U.S. EPA 2000). Physicochemical results are arranged to demonstrate trends of certain variables that may suggest a source of effects at the Little Lindley Creek test stations. Results shown here are for stream discharge, nitrate + nitrite-N, total nitrogen, total phosphorus, and turbidity by season.

3.3.1 Stream Discharge

Discharge was low during both sampling seasons at the Little Lindley Creek test stations and the Ingalls Creek candidate reference station. Discharge was 1.3 cubic feet per second (cfs) at Little Lindley Creek #1, 2.4 cfs at Little Lindley Creek #2, and 0.1 cfs at Ingalls Creek #1 during the fall 2011 sampling season. During the spring 2012 sampling season, discharge was slightly higher at most of the sampling stations with values of 3.7 cfs at Little Lindley Creek #1, 1.8 cfs at Little Lindley Creek #2, and 3.7 cfs at Ingalls Creek #1.

3.3.2 Nitrate + Nitrite-N

Nitrate + nitrite-N was elevated at Little Lindley Creek test stations during both sampling seasons. There are no water quality standards for Nitrate + nitrite-N, but the values of 3.61 mg/L at test station #1 and 3.45 mg/L at test station #2 were much higher during the fall 2011 sampling season than the U.S. EPA recommended reference value of 0.24 mg/L for the Level III Ozark Highlands ecoregion (U.S. EPA 2000). Nitrate + nitrite-N values also were much higher than the recommended reference value during the spring 2012 sampling season, with concentrations of 1.93 mg/L at test station #1 and 4.27 mg/L at test station #2. The nitrate + nitrite-N concentration at Ingalls Creek was slightly higher than the recommended reference value in fall 2011, with a value of 0.28 mg/L, but the spring 2012 value of 0.02 mg/L was much lower than recommended reference conditions.

3.3.3 Total Nitrogen

Total nitrogen was elevated at Little Lindley Creek test stations during both sampling seasons. There are no water quality standards for total nitrogen, but the values of 3.83 mg/L at test station #1 and 4.05 mg/L at test station #2 were much higher during the fall 2011 compared to the U.S. EPA recommended reference value of 0.38 mg/L for the Level III Ozark Highlands ecoregion (U.S. EPA 2000). During the spring 2012 sampling season, total nitrogen values were also much higher than recommended reference conditions at the test stations, with concentrations of 2.46 mg/L at test station #1 and 5.11 mg/L at test station #2. Total nitrogen concentration at Ingalls Creek was slightly higher than the recommended reference value during the fall 2011 sampling season with a value of 0.39 mg/L, but the spring 2012 value of 0.14 mg/L was much lower than reference conditions.

3.3.4 Total Phosphorus

Total phosphorus was elevated at Little Lindley Creek test stations during both sampling seasons. There are no water quality standards for Total phosphorus, but the values of 0.76 mg/L at test station #1 and 0.87 mg/L at test station #2 were much higher during the fall 2011 sampling season than the U.S. EPA recommended reference value of 0.007

mg/L for the Level III Ozark Highlands ecoregion (U.S. EPA 2000). During the spring 2012 sampling season, values were also much higher than recommended reference conditions at the test stations, with concentrations of 0.42 mg/L at test station #1 and 0.67 mg/L at test station #2. The total phosphorus concentration at the Ingalls Creek control station was slightly higher than recommended reference conditions during both sample seasons. The fall 2011 total phosphorus concentration was 0.02 mg/L and the spring 2012 value was 0.01 mg/L.

3.3.5 Turbidity

Turbidity was elevated at Little Lindley Creek #2 and Ingalls Creek during the fall 2011 sampling season. None of the sampling stations had elevated turbidity values during the spring 2012 sampling season, however. There are no water quality standards for turbidity, but the values of 1.60 NTU at Little Lindley Creek #2 and 2.21 NTU at Ingalls Creek were slightly higher during the fall 2011 sampling season than the U.S. EPA recommended reference value of 1.43 NTU for the Level III Ozark Highlands ecoregion (U.S. EPA 2000). Little Lindley Creek #1 was lower than the recommended reference value with a turbidity reading of 0.92 NTU. During the spring 2012 sampling season, turbidity was lower than the recommended reference value at all of the sampling stations. Turbidity was 1.04 NTU at Little Lindley Creek #1, 1.42 NTU at Little Lindley Creek #2, and 0.50 NTU at Ingalls Creek.

Table 10
Physicochemical Variables at the Little Lindley Creek Bioassessment Study Sampling Stations, Fall 2011 and Spring 2012

	L. Lindley Creek #1	L. Lindley Creek #2	Ingalls Creek #1
Fall 2011 Sampling Season			
Invertebrate Sample Number	110983	110984	110985
Physicochemical Sample Number	1107126	1107125	1107124
Sample Date	09/20/2011	09/19/2011	09/19/2011
Sample Time	1240	1420	1113
Ammonia	<0.03*	0.44	<0.03*
Chloride	29.2	28.0	6.39
Dissolved Oxygen	9.15	9.52	6.33
Discharge (cfs)	1.3	2.4	0.1
pH (Units)	7.8	8.1	7.6
Conductivity (µmhos/cm)	448	420	363
Temperature (°C)	18.4	19.5	18.5
Turbidity (NTU)	0.92	**1.60**	**2.21**
Total Suspended Solids	<5*	<5*	<5*
Nitrate + Nitrite	**3.61**	**3.45**	**0.28**
Total Nitrogen	**3.83**	**4.05**	**0.39**
Total Phosphorus	**0.76**	**0.87**	**0.02****
Spring 2012 Sampling Season			
Invertebrate Sample Number	120021	120022	120023
Physicochemical Sample Number	1202925	1202926	1202927
Sample Date	03/19/2012	09/19/2012	03/19/2012
Sample Time	1145	1000	1335
Ammonia	<0.03*	0.04**	<0.03*
Chloride	32.8	38.9	9.40
Dissolved Oxygen	11.49	9.69	10.72
Discharge (cfs)	3.7	1.8	3.7
pH (Units)	8.5	8.3	8.5
Conductivity (µmhos/cm)	467	497	410
Temperature (°C)	19.2	17.5	19.3
Turbidity (NTU)	1.04	1.42	0.50
Total Suspended Solids	<5*	<5*	<5*
Nitrate + Nitrite	**1.93**	**4.27**	0.02
Total Nitrogen	**2.46**	**5.11**	0.14**
Total Phosphorus	**0.42**	**0.67**	**0.01**

*Below detectable limits
**Estimated value, detected below Practical Quantitation Limit
Units mg/L unless otherwise noted. Values in bold are elevated compared to U.S. EPA recommended reference condition values.

4.0 Data Trends

4.1 Macroinvertebrate Biological Assessment

4.1.1 MSCI and Biological Metrics

A comparison of the MSCI scores between the 2002-2003 study and the current study (2011-2012) showed that both Little Lindley Creek test stations had higher MSCI scores in the current study for the fall sampling season and the same MSCI scores during the

spring sampling season (Table 11). Both test stations had fully supporting MSCI scores of 16 during the fall 2011 sampling season compared to partially supporting MSCI scores of 12 at test station #1 and 10 at test station #2 during the fall 2002 sampling season. Results from the spring sampling season showed that for each test station, the 2012 MSCI scores were the same as the 2003 scores. Station #1 had a partially supporting MSCI score of 12 and test station #2 had a partially supporting score of 10.

Many of the biological metrics showed improvement during the current study compared to the 2002-2003 study even though MSCI scores were still low during the spring sampling season (Table 11). During the fall sampling season, the 2011 results for TR and SDI were higher and BI was lower at both test stations compared to 2002 results. The number of EPTT was the same at Little Lindley Creek #1 and twice as high at Little Lindley Creek #2 in 2011 compared to 2002 results. The results were more mixed for the spring sampling season, but some of the biological metrics showed marked improvement in 2012 compared to the 2003 results. At Little Lindley Creek #1, TR and SDI were higher and BI was lower in 2012. The only metric that did not improve was EPTT, which was 16 in 2003, compared to 12 in 2012. The results at Little Lindley Creek #2 showed that TR and BI improved compared to the results in 2003, but SDI and EPTT declined.

4.1.2 Macroinvertebrate Community Composition

Percent EPTT was much higher in the 2002-2003 Little Lindley Creek samples than the samples collected for the current study during both seasons (Tables 12 and 13). Percent Ephemeroptera made up most of the difference in percent EPTT between the two studies. The mayfly *Caenis latipennis* was much more abundant at both sampling stations during the 2002-2003 study than the 2011-2012 study. The heptageniid mayfly *Stenonema femoratum* was also more abundant in 2002-2003 than 2011-2012. Other differences in the macroinvertebrate community during fall sampling season included higher abundance of the tolerant amphipod *Hyalella azteca* and Planariidae during the 2002 sampling season and higher abundance of the water pennies *Psephenus herricki* and *Ectopria nervosa*, the caddisfly *Cheumatopsyche*, and tubificid worms during the 2011 sampling season. During the spring sampling season, other differences included a much higher abundance of the amphipod *Crangonyx* at both test stations in 2003, higher abundance of *Eukiefferiella* at both test stations in 2012, a much higher abundance of *Dicrotendipes* at test station #2 in 2012, a higher abundance of *Cricotopus/Orthocladius* group at test station #2 in 2012, and much higher abundances for *Simulium* and *Elimia* at test station #1 in 2012. Some taxa, such as the riffle beetle *Stenelmis* and the chironomids *Dicrotendipes* and *Cricotopus/Orthocladius* group, were similarly abundant during both study periods of 2002-2003 and 2011-2012 and both sample seasons. Other taxa, including the baetid mayfly *Baetis* and Planariidae, exhibited this similarity only during the spring sampling season.

Quantitative Similarity Index (**QSI**) was used to determine the macroinvertebrate community similarity between the samples collected in 2002-2003 and the samples

collected in 2011-2012 at each sampling station. The results of the QSI showed that samples between the sampling periods were not that similar for either sampling season (Tables 12 and 13). QSI at test station #1 was 40.4 during the fall sampling season and 43.8 during the spring sampling season. At test station #2, the QSI was 54.0 during the fall sampling season and 49.3 during the spring sampling season.

4.2 Physicochemical Data

A comparison of water quality data from the 2002-2003 study and the current study showed elevated nutrient concentrations during both sampling periods (Table 14). The main difference between the earlier study and the current study was that chloride, conductivity, nitrate + nitrite-N, and total phosphorus had much higher concentrations, but discharge was much lower during the fall 2002 sampling season than either sampling season for the current study. Turbidity was also elevated during both sampling seasons at both stations in the previous study, but in the current study turbidity was slightly above the U.S. EPA recommended reference values (U.S. EPA 2000) only at test station #2 in spring. Total Kjeldahl Nitrogen (TKN) was higher than the U.S. EPA recommended concentrations of 0.05 mg/L (U.S. EPA 2000a) during the spring sampling season at both test stations in the previous study. No comparison between studies was made for TKN and total nitrogen because TKN was not collected in the current study and total nitrogen was not collected in the previous study.

Table 11
Riffle/Pool Ozark/Osage EDU Perennial/Wadeable Biological Criteria, Biological Support Categories, and Macroinvertebrate Stream Condition Index (MSCI) Scores at the Little Lindley Creek Test Stations

Station	Sample Year	Sample No.	TR	EPTT	BI	SDI	MSCI	Support
Fall Sampling Season								
Little Lindley Creek #1	2002	0218111	66	12	6.9	2.49	12	P
	2011	110983	79	12	5.9	3.34	16	F
Little Lindley Creek #2	2002	0218112	49	6	6.9	2.82	10	P
	2011	110984	70	12	6.4	3.46	16	F
Metric Score=5	If		>84	>18	<6.7	>3.22	20-16	**F**ull
Metric Score=3	If		84-42	18-9	6.7-8.3	3.22-1.61	14-10	**P**artial
Metric Score=1	If		<42	<9	>8.3	<1.61	8-4	**N**on
Spring Sampling Season								
Little Lindley Creek #1	2003	0318687	70	16	6.9	2.96	12	P
	2012	120021	79	12	5.5	3.07	12	P
Little Lindley Creek #2	2003	0318688	51	9	7.0	2.91	10	P
	2012	120022	63	8	6.5	2.71	10	P
Metric Score=5	If		>90	>25	<6.2	>3.16	20-16	**F**ull
Metric Score=3	If		90-45	25-13	6.2-8.1	3.16-1.58	14-10	**P**artial
Metric Score=1	If		<45	<13	>8.1	<1.58	8-4	**N**on

Table 12
Percent EPT, Dominant Macroinvertebrate Families, Macroinvertebrate Taxa, and Quantitative Similarity Index (QSI) at the Little Lindley Creek Test Stations, Fall 2002 and 2011

Variable-Station	**Biotic Index**	**Little Lindley Creek #1**		**Little Lindley Creek #2**	
Sample Number		0218111	110983	0218112	110984
Sample Date		09/25/02	09/20/11	09/24/02	09/19/12
EPT Metrics					
% EPT	*	60.8	33.4	34.6	23.9
% Ephemeroptera	*	54.3	19.5	30.7	17.4
% Plecoptera	*				
% Trichoptera	*	6.4	13.9	3.9	6.0
Percent Dominant Families					
Caenidae	7.0	**40.7**	1.6	**17.2**	1.0
Chironomidae	8.0	**12.3**	**12.8**	**17.2**	**23.8**
Heptageniidae	4.0	**11.3**	6.2	3.9	5.8
Planariidae	*	**6.8**	5.1	**13.4**	1.5
Elmidae	4.0	**4.6**	**17.6**	**16.0**	**14.6**
Psephenidae	*	4.3	**11.9**	0.2	**11.8**
Baetidae	4.0	2.3	**9.6**	**9.6**	**10.5**
Hydropsychidae	4.0	1.6	**8.1**	2.5	4.5
Tubificidae	9.2	0.6	1.8	1.6	**6.2**
Percent Dominant Taxa					
Caenis latipennis	7.6	**40.7**	1.6	**17.2**	1.0
Stenonema femoratum	7.5	**10.6**	3.7	3.5	1.9
Planariidae	7.5	**6.8**	**5.1**	**13.4**	1.5
Stenelmis	5.4	**4.2**	**12.4**	**15.2**	**11.8**
Psephenus herricki	2.5	**4.2**	**10.5**	0.2	**6.9**
Hyalella azteca	7.9	3.8	1.0	**6.0**	1.5
Cheumatopsyche	6.6	1.6	**8.1**	2.5	4.5
Baetis	6.0	1.8	**9.5**	**9.6**	**9.8**
Tubificidae	9.2	0.3	1.3	1.6	**5.2**
Ectopria nervosa	4.3	0.1	1.4		**4.9**
Quantitative Similarity Index (QSI)		40.4		54.0	

*Biotic index values were not available for these taxa

Table 13
Percent EPT, Dominant Macroinvertebrate Families, Macroinvertebrate Taxa, and Quantitative Similarity Index (QSI) at the Little Lindley Creek Test Stations, Spring 2003 and 2012

Variable-Station	**Biotic Index**	**Little Lindley Creek #1**		**Little Lindley Creek #2**	
Sample Number		0318687	120021	0318688	120022
Sample Date		04/01/03	03/19/12	04/01/03	03/19/12
EPT Metrics					
% EPT	*	33.5	3.8	20.5	2.7
% Ephemeroptera	*	30.0	1.1	19.5	1.0
% Plecoptera	*	2.4	0.9		0.1
% Trichoptera	*	1.2	1.8	1.0	1.6
Percent Dominant Families					
Chironomidae	8.0	**35.1**	**58.7**	**42.8**	**78.5**
Caenidae	7.0	**21.2**	0.3	**15.0**	0
Crangonyctide	*	**11.7**	2.7	**5.2**	1.8
Elmidae	4.0	**8.3**	**8.5**	**16.7**	**5.8**
Simuliidae	6.0		**8.9**		**2.0**
Pleuroceridae	*	0.3	**6.0**		0
Planariidae	7.5	5.0	**3.9**	**4.4**	0.6
Psephenidae	*	1.5	1.0	0.1	**3.0**
Tubificidae	9.2	0.1	0.7	2.6	**2.2**
Heptageniidae	4.0	**8.6**	4.0	4.0	1.0
Percent Dominant Taxa					
Caenis latipennis	7.6	**21.2**	0.3	**15.0**	
Crangonyx	8.0	**11.7**	2.7	**5.2**	1.8
Stenelmis	5.4	**8.3**	**8.1**	**16.6**	**5.6**
Stenonema femoratum	7.5	**7.1**	0.3	3.8	0.3
Dicrotendipes	7.9	**6.0**	**7.7**	**8.5**	**25.4**
Eukiefferiella	4.0	4.6	**23.6**	0.6	**9.1**
Cricotopus/Orthocladius Grp.	6.5	5.0	3.5	**11.9**	**20.7**
Eukiefferiella	4.0	4.6	**23.6**	0.6	**9.1**
Simulium	4.4		**8.9**		2.0
Elimia	2.5	0.3	**6.0**		
Polypedilum convictum	5.3	3.2	0.7	3.8	**5.7**
Quantitative Similarity Index (QSI)		43.8		49.3	

*Biotic index values were not available for these taxa

Table 14
Physicochemical Variables at the Little Lindley Creek Bioassessment Study Sampling Stations, 2002-2003 and 2011-2012 Sampling Seasons

	Little Lindley Creek #1		**Little Lindley Creek #2**	
Fall Sampling Season				
Invertebrate Sample Number	0218111	110983	0218112	110984
Physicochemical Sample Number	0228683	1107126	0228682	1107125
Sample Date	09/25/2002	09/20/2011	09/24/2002	09/19/2011
Sample Time	0755	1240	1645	1420
Ammonia	<0.05*	<0.03*	<0.05*	0.44
Chloride	67.9	29.2	68.9	28.0
Dissolved Oxygen	6.20	9.15	10.10	9.52
Discharge (cfs)	0.32	1.30	0.43	2.42
pH (Units)	7.4	7.8	7.9	8.1
Conductivity (µmhos/cm)	743	448	780	420
Temperature (°C)	16.0	18.4	18.5	19.5
Turbidity (NTU)	**6.61**	0.92	**1.50**	**1.60**
Total Suspended Solids		<5*		<5*
Nitrate + Nitrite-N	**15.9**	**3.61**	**22.4**	**3.45**
TKN	<0.2*		<0.2*	
Total Nitrogen		**3.83**		**4.05**
Total Phosphorus	**1.81**	**0.76**	**4.22**	**0.87**
Spring Sampling Season				
Invertebrate Sampling Season	0318687	120021	0318688	120022
Physicochemical Sample Number	0300811	1202925	0300812	1202926
Sample Date	04/01/2003	03/19/2012	04/01/2003	03/19/2012
Sample Time	1000	1145	0820	1000
Ammonia	<0.05*	<0.03*	<0.05*	0.04**
Chloride	34.8	32.8	39.1	38.9
Dissolved Oxygen	12.00	11.49	7.80	9.69
Discharge	6.28	3.68	5.08	1.76
pH (Units)	8.27	8.5	7.88	8.3
Conductivity (µmhos/cm)	412	467	422	497
Temperature (°C)	11.5	19.2	10.0	17.5
Turbidity (NTU)	**5.75**	1.04	**7.80**	1.42
Total Suspended Solids		<5*		<5*
Nitrate + Nitrite-N	**1.08**	**1.93**	**4.43**	**4.27**
TKN	**0.34**		**0.54**	
Total Nitrogen		**2.46**		**5.11**
Total Phosphorus	**0.41**	**0.42**	**0.45**	**0.67**

*Below detectable limits
**Estimated value, detected below Practical Quantitation Limit
Units mg/L unless otherwise noted. Values in bold are elevated compared to water quality standards or U.S. EPA recommended reference condition values.

5.0 Discussion

5.1 Effect of Stream Size on MSCI Scores

Stream size appeared to have more of an effect on biological criteria and MSCI scores in the fall 2011 than the spring 2012 sample season (Tables 4 and 5). During the fall 2011 sampling season, EPTT was slightly lower and TR, BI, and SDI biological criteria values were much higher for the perennial/wadeable streams than the candidate reference streams. These differences in fall biological criteria metrics led to two of the three fall 2011 samples (Little Lindley Creek #2 and Ingalls Creek #1) having MSCI scores in different support categories based on stream size. The Little Lindley Creek samples had fully supporting MSCI scores of 16 when biological criteria were used. When candidate reference criteria were used, however, Little Lindley Creek #2 had a partially supporting MSCI score of 14 and Ingalls Creek #1 had a partially supporting MSCI score of 12. The lower criteria value for BI and higher EPTT criteria value for the candidate reference criteria led to the difference in the MSCI scores at Little Lindley Creek #2 and Ingalls Creek #1 during the fall 2011 sampling season.

The biological criteria metric values calculated using candidate reference streams were more similar to values calculated using perennial/wadeable reference streams during the spring sampling season. Two of the metrics had very similar criteria values between the stream sizes. The TR value was slightly lower and the EPTT value was slightly higher for the perennial/wadeable streams. There was more of a difference for the other two metrics between the stream sizes. The SDI metric was slightly higher and the BI metric had a lower value for candidate reference criteria. The differences in the metric values led to a change in the MSCI score at one of the sampling stations. Little Lindley Creek #1 had a partially supporting score of 12 using the perennial/wadeable biological criteria and a partially supporting MSCI score of 14 using the candidate reference stream criteria. The difference in the MSCI score for this station was caused by the slightly lower EPTT criteria value for the candidate reference streams. There were differences in the biological criteria based on stream size during both sampling seasons, but the Little Lindley Creek and Ingalls Creek MSCI scores were in the same or higher support category using the perennial/wadeable biological reference streams as the MSCI scores using the candidate reference stream criteria.

5.2 Nutrient Enrichment Effects on MSCI Scores

Results from the surface water samples showed that nitrate + nitrite-N, total nitrogen, and total phosphorus were elevated compared to the Ingalls Creek candidate reference station and U.S. EPA recommended reference values (U.S. EPA 2000). These results were similar to what was found during the earlier biological assessment study during the fall 2002 and spring 2003 sampling seasons (Table 14). The main difference between the earlier study and the current study was that chloride, conductivity, nitrate + nitrite-N, and total phosphorus had much higher concentrations and discharge was much lower during the fall 2002 sampling season than either sampling season for the current study.

The Little Lindley Creek test stations and the Ingalls Creek candidate reference station had fully supporting MSCI scores of 16 during the fall 2011 sampling season using the perennial/wadeable biological criteria (Table 4). But during the spring 2012 sampling season, Little Lindley Creek #1 had a partially supporting MSCI score of 12 and Little Lindley Creek #2 had a partially supporting MSCI score of 10. The Ingalls Creek station had a fully supporting MSCI score of 18 during the spring 2012 sampling season. The Little Lindley Creek spring 2012 sampling season results were similar to the results of the 2002-2003 biological assessment study, which had the same MSCI scores during both sampling seasons (Table 11). During the fall 2011 sampling season, TR and EPTT scored in the partially supporting range, leading to the MSCI score of 16 at both Little Lindley Creek test stations. The lower MSCI score of 10 at Little Lindley Creek #2 during the spring 2012 sampling season was caused by TR, BI, and SDI scoring in the partially supporting range and EPTT in the non-supporting range. The results were similar at Little Lindley Creek #1 during the spring 2012 sampling season, except that BI scored in fully supporting range, which led to an MSCI score of 12. Compared to the perennial/wadeable biological criteria, the biological metric results during both sampling seasons at the Little Lindley Creek test stations showed that the macroinvertebrate community was less diverse and had fewer EPTT, which are generally considered more pollutant sensitive than other taxa. The spring 2012 results, like the fall 2011 season, showed that TR and EPTT were much lower than biological criteria and the lower SDI values indicated that the macroinvertebrate community was less diverse and represented by fewer taxa. Biotic index values at the Little Lindley Creek sampling stations were similar between sampling seasons, but the biotic index criteria value for the spring sampling season was lower than fall season criteria, leading to the lower metric score at Little Lindley Creek #2.

A comparison of the biological metrics between the 2002-2003 study and the current study showed that many of the biological metric values showed improvement even though the spring 2012 sampling season had low MSCI scores (Table 11). Three of the biological metrics--TR, BI, and SDI--showed improvement during the fall sampling season at both test stations in 2011 compared to the results of 2002. During the spring sampling season, TR, BI, and SDI showed improvement at Little Lindley Creek #1 and TR and BI improved at Little Lindley Creek #2 in 2012 compared to 2003. Another difference between the two studies was that percent EPTT was lower in 2011-2012 than the 2002-2003 study during both sampling seasons (Tables 12 and 13). But the higher percent EPTT in 2002-2003 was mostly the result of a much greater abundance of two tolerant mayfly taxa, *Caenis latipennis* and *Stenonema femoratum*. The overall results of the current study showed that the Little Lindley Creek macroinvertebrate community was more diverse with a lower proportion of tolerant organisms compared to 2002-2003, which suggests that water quality conditions may have improved since the previous study.

5.3 Macroinvertebrate Community Composition

The Little Lindley Creek test stations had a lower percentage of EPTT than biocriteria reference data, candidate reference data, and the Ingalls Creek candidate reference station during both sampling seasons (Tables 7 and 9). In fall 2011, percent Ephemeroptera accounted for most of the lower percent EPTT values at the Little Lindley Creek test stations. The lower percent EPTT values at the Little Lindley Creek test stations were much more pronounced during the spring 2012 sampling season. The results from spring 2012 showed that the low percent EPTT value was caused by the very low percent Ephemeroptera and Plecoptera values at the Little Lindley Creek test stations compared to reference conditions.

Most of the dominant macroinvertebrate taxa found in Little Lindley Creek samples during fall 2011 had BI values in the intolerant (BI 2.5-5.0) and moderately tolerant (BI 5.0-7.5) ranges (Figure 4 and Table 7). The only exception was at Little Lindley Creek #2, in which about 5 percent of the sample was made up of tubificid worms (BI = 9.2). Both test stations had a high abundance of the moderately tolerant elmid beetle *Stenelmis*, the intolerant water penny *Psephenus herricki*, and the moderately tolerant baetid mayfly *Baetis*. Test station #1 also had a high abundance of the moderately tolerant hydropsychid caddisfly *Cheumatopsyche* and the moderately tolerant Planariidae, whereas test station #2 had a high abundance of tolerant tubificid worms and the intolerant water penny *Ectopria nervosa*.

The biocriteria reference streams, the candidate reference streams, and the Ingalls Creek station for the fall 2011 sampling season had a higher percentage of samples made up of EPTT than the Little Lindley Creek test stations, but the biggest part of that metric was the high abundance of the tolerant caenid mayfly *Caenis latipennis*. Other common EPTT taxa included the moderately tolerant leptohyphid mayfly *Tricorythodes* at the biocriteria reference streams, the moderately tolerant hydropsychid caddisfly *Cheumatopsyche* at the biocriteria and candidate reference streams, and the intolerant baetid mayfly *Acerpenna* and the very intolerant leptophlebid mayfly *Choroterpes* at the Ingalls Creek candidate reference station. Another difference between the Little Lindley Creek test stations and reference conditions, was that the water penny *P. herricki* was much lower in abundance at the biocriteria reference streams and the Ingalls Creek candidate reference station. *P. herricki* was one of the most common taxa found in the candidate reference streams, but it still was in lower abundance than the Little Lindley Creek test stations. These results indicate a difference in the macroinvertebrate community structure between the Little Lindley Creek test stations and the reference conditions. There was not, however, strong evidence that the elevated nutrient levels in the fall water samples were causing impairment of Little Lindley Creek since the overall biotic index values were similar to reference conditions.

During the spring 2012 sampling season, chironomids made up a much higher percentage of the Little Lindley Creek samples and test station #1 had a higher abundance of intolerant organisms than test station #2 (Figure 7; Tables 8 and 9). Intolerant taxa that

were found in higher abundance at test station #1 were the orthoclad chironomid *Eukiefferiella*, the black fly *Simulium*, and the pleurocerid snail *Elimia*. At test station #2, two chironomid taxa, the tolerant Chironomini *Dicrotendipes* and the moderately tolerant orthoclad *Cricotopus/Orthocladius* group made up about 56 percent of the sample. Chironomids also made up a high percentage of the spring biocriteria reference data, the candidate reference data, and the Ingalls Creek station, but EPTT also made up a much higher percentage of the samples compared to the Little Lindley Creek test stations. The tolerant mayfly *C. latipennis* was common in both reference datasets and Ingalls Creek. Other EPTT that were common in the reference streams were the baetid mayfly *Acentrella* at the candidate reference streams and Ingalls Creek station and the intolerant perlodid stonefly *Isoperla* at the Ingalls Creek station. The higher abundance of tolerant taxa such as *Dicrotendipes*, the much higher concentrations of nitrogen and phosphorus in the water samples, and an overall biotic index value higher than reference conditions for the spring 2012 sampling season indicate that the macroinvertebrate community was being affected by nutrient enrichment at Little Lindley Creek #2.

A comparison between the present study versus the 2002-2003 study showed that there were differences in the macroinvertebrate community composition (Tables 12 and 13). The Quantitative Similarity Index (QSI) values between the samples collected in 2002-2003 and the samples collected in 2011-2012 were low and indicated that there were differences in the macroinvertebrate community composition during the two sampling periods. QSI values were around 40 percent at test station #1 and 50 percent at test station #2 during both sampling seasons. Shackleford (1988) indicated that QSI values less than 65 percent could indicate environmental stress. The biggest difference between the two studies was the much higher abundance in 2002-2003 of tolerant mayfly taxa *C. latipennis* and *Stenonema femoratum* during both sampling seasons, higher abundance of tolerant amphipod *Hyalella azteca* and Planariidae during the fall sampling season, and a higher abundance of the tolerant amphipod *Crangonyx* during the spring sampling season. During the 2011-2012 study, mayflies were not among the most abundant macroinvertebrate taxa in test stations, but more intolerant taxa were present than in the 2002-2003 study. The only mayfly that was common in the 2011-2012 samples was the moderately tolerant *Baetis*, which made up about 10 percent of samples at both test stations during the fall sampling season. Other taxa that were more abundant in the 2011-2012 study during the fall sampling season included the moderately tolerant caddisfly *Cheumatopsyche* at both sampling stations, tubificid worms at test station #2, the intolerant water penny *P. herricki* at both sampling stations, and the intolerant water penny *E. nervosa* at test station #2. Taxa that were more abundant in spring 2012 than spring 2003 were the intolerant chironomid *Eukiefferiella* at both test stations, the tolerant chironomid *Dicrotendipes* at test station #2, the moderately tolerant *Cricotopus/Orthocladius* group at test station #2, and the intolerant black fly *Simulium* and the intolerant pleurocerid snail *Elimia* at test station #1. These results during both sampling seasons showed that some of the same taxa were common in both studies, but the sampling stations during the 2002-2003 study had much higher abundances of

tolerant mayflies and amphipods, whereas other taxa groups, which were generally more intolerant, were more common in the 2011-2012 study.

5.4 Functional Feeding and Habitat Groups

The FFG and FHG analysis showed some trends that varied by sample season and indicated some possible changes related to water quality. The FFG scrapers and the FHG clingers were higher in abundance at the Little Lindley Creek test stations than reference conditions during the fall 2011 sampling season (Figures 5 and 6; Table 6). Both of these metrics are considered indicators of good water quality and tend to decline with decreasing hard substrates and increased sedimentation (Rabeni et al. 2005). Two other FHGs, climbers and sprawlers, were much less abundant at both Little Lindley Creek test stations compared to reference conditions. These FHGs are considered to be indicators of poorer water quality conditions, especially in cases of increased sedimentation.

The spring 2012 FFG and FHG composition differed between Little Lindley Creek test stations (Figures 8 and 9; Table 8). Scrapers were more abundant at Little Lindley Creek #1 than reference conditions. In contrast, the abundance of scrapers at Little Lindley Creek #2 was below reference condition values. The percentage of clingers was much lower during the spring 2012 sampling season compared to fall 2011 and was not much higher than reference conditions. Clingers were slightly less abundant than reference conditions at test station #1 but similar to references at test station #2. Percent climbers was slightly lower than perennial/wadeable and candidate reference conditions at both test stations, but percent sprawlers was higher at test station #1 and much lower at test station #2 compared to reference conditions. The results of these two metrics were inconclusive since both metrics generally indicate poorer water quality conditions. A much higher percentage of burrowers was present at Little Lindley Creek #2 than Little Lindley Creek #1 and reference conditions. Percent burrowers at test station #1 were slightly lower than biocriteria reference data and higher than the candidate reference data and the Ingalls Creek station. Burrowers are indicative of poorer water quality conditions and are considered the most sediment tolerant FHG (Rabeni et al. 2005). Functional feeding and habitat group results during the spring 2012 sampling season were more inconclusive than the fall 2011 sampling season; however, the relatively low percentage of scrapers and high abundance of burrowers at test station #2 does suggest that water quality conditions were possibly more degraded at this site.

6.0 Conclusions

Both Little Lindley Creek test stations had fully supporting MSCI scores of 16 in fall 2011when using Ozark/Osage EDU biological criteria. During the spring 2012 sampling season, however, both Little Lindley Creek sampling stations had MSCI scores in the partially supporting range, with Little Lindley Creek #1 having a score of 12 and Little Lindley Creek #2 scoring 10. Biological criteria and candidate reference criteria resulted in different support categories for Little Lindley Creek #2 and Ingalls Creek #1 for the fall 2011sampling season. The difference in MSCI scores between the two criteria data

sets during the fall sampling season was due to differences in the EPTT and BI biological metrics.

The first null hypothesis stated that the macroinvertebrate community will not differ between longitudinally separate reaches of Little Lindley Creek. The second null hypothesis stated that the macroinvertebrate assemblages in the Little Lindley Creek samples will be similar to the Ozark/Osage EDU wadeable/perennial stream biological criteria. These two null hypotheses were rejected based on both Little Lindley Creek stations having partially supporting MSCI scores in spring 2012.

The third hypothesis stated that the macroinvertebrate assemblages in the Little Lindley Creek samples will be similar to the Ozark/Osage EDU candidate reference stream criteria. This hypothesis was rejected since Little Lindley Creek #2 had a partially supporting score in fall 2011 and both sampling stations had partially supporting candidate reference criteria MSCI scores in spring 2012.

The fourth hypothesis stated that physicochemical water quality in Little Lindley Creek will meet the WQS of Missouri (MDNR 2012a). This hypothesis was accepted since no WQS were violated. Nitrate + nitrite-N, total nitrogen, and total phosphorus were higher than U.S. EPA recommended reference values in the surface water samples from Little Lindley Creek, but there are currently no Missouri WQS for these constituents in surface water.

The fifth hypothesis stated that physicochemical water quality will not differ between longitudinally separate reaches of Little Lindley Creek. This hypothesis was rejected since nitrate + nitrite-N, total nitrogen, and total phosphorus were higher at Little Lindley Creek #2 than Little Lindley Creek #1 during the spring 2012 sampling season.

7.0 References Cited

Missouri Department of Natural Resources. 2002. Biological Criteria for Wadeable/Perennial Streams of Missouri. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 32 pp.

Missouri Department of Natural Resources. 2003. Biological Assessment Study. Little Lindley Creek, Dallas County, 2002-2003. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 18 pp.

Missouri Department of Natural Resources. 2004. Biological Assessment Study. Town Branch/Piper Creek, Polk County, 2003-2004. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 26 pp.

Missouri Department of Natural Resources. 2007. Little Lindley Creek Total Maximum Daily Load Information Sheet. Missouri Department of Natural Resources, Water Protection Program, Water Pollution Control Branch, P.O. Box 176, Jefferson City, Missouri. 3 pp.

Missouri Department of Natural Resources. 2010a. Field Sheet and Chain-of-Custody Record. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 14 pp.

Missouri Department of Natural Resources. 2010b. Flow Measurements in Open Channels. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 12 pp.

Missouri Department of Natural Resources. 2011. Required/Recommended Containers, Volumes, Preservatives, Holding Times, and Special Sampling Considerations. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 27 pp.

Missouri Department of Natural Resources. 2012a. Title 10. Rules of Department of Natural Resources Division 20-Clean Water Commission, Chapter 7-Water Quality. 10 CSR 20-7.031 Water Quality Standards. pp. 10-136.

Missouri Department of Natural Resources. 2012b. Stream Habitat Assessment Project Procedure. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri. 40 pp.

Missouri Department of Natural Resources. 2012c. Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 26 pp.

Rabeni, C.E., K.E. Doisy, L.D. Zweig. 2005. Stream Invertebrate Community Functional Responses to Deposited Sediment. Aquatic Sciences 67:395-402.

Shackleford, B. 1988. Rapid Bioassessment of Lotic Macroinvertebrate Communities. Arkansas Dept. of Pollution Control and Ecology, Little Rock, Arkansas. 44 pp.

Sowa, S.P., D.D. Diamond, R.A. Abbitt, G.M. Annis, T. Gordon, M.E. Morey, G.R. Sorensen, and D. True. 2004. Final Report of the Aquatic Component of GAP Analysis: A Missouri Prototype. Missouri Resource Assessment Partnership (MoRAP), University of Missouri. 111 pp.

Sowa, S., and D. Diamond. 2006. Using GIS and an Aquatic Ecological Classification System to Classify and Map Distinct Riverine Ecosystems Throughout EPA Region 7. Missouri Resource Assessment Partnership (MoRAP), University of Missouri. 242 pp.

United States Environmental Protection Agency. 2000. Ambient Water Quality Criteria Recommendations. Information Supporting the Development of State and Tribal Nutrient Criteria for River and Streams in Nutrient Ecoregion XI. United States Environmental Protection Agency, Office of Water, Washington, D.C., EPA-822-B-00-020. 28 pp.

Submitted by: _____

Carl Wakefield
Environmental Specialist
Water Quality Monitoring Section
Environmental Services Program

Date: _____

Approved by: _____

Alan Reinkemeyer
Director
Environmental Services Program

AR:cwt

c: Trish Rielly, QAPP Project Manager, WPP
Cindy Davies, Southwest Regional Office

Appendix A

Little Lindley Creek Macroinvertebrate Taxa Lists

Aquid Invertebrate Database Bench Sheet Report

Little Lindley Cr [110983], Station #1, Sample Date: 9/20/2011 1:00:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina		1	
AMPHIPODA			
Crangonyx	21	7	11
Hyalella azteca		1	13
ARHYNCHOBDELLIDA			
Erpobdellidae	-99		
COLEOPTERA			
Berosus	4	3	2
Dubiraphia		11	51
Ectopria nervosa	2	17	
Enochrus	1		
Helichus basalis			1
Hydrophilidae			1
Macronychus glabratus			8
Peltodytes			1
Psephenus herricki	119	20	1
Scirtidae			1
Stenelmis	94	10	62
DECAPODA			

Aquid Invertebrate Database Bench Sheet Report

Little Lindley Cr [110983], Station #1, Sample Date: 9/20/2011 1:00:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Orconectes luteus	-99		-99
Orconectes virilis			1
DIPTERA			
Ablabesmyia		7	
Ceratopogoninae	2	5	2
Chironomidae		1	1
Corynoneura	1	2	
Cryptochironomus		2	1
Dicrotendipes	1	6	8
Labrundinia			5
Larsia	1		
Micropsectra			1
Microtendipes		1	1
Nanocladius			1
Nilotanypus	5	1	
Paraphaenocladius		1	
Paratanytarsus			1
Paratendipes		1	
Phaenopsectra		1	
Polypedilum convictum	27		

Aquid Invertebrate Database Bench Sheet Report

Little Lindley Cr [110983], Station #1, Sample Date: 9/20/2011 1:00:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Polypedilum illinoense grp	1	1	5
Polypedilum scalaenum grp		1	1
Procladius		1	
Pseudochironomus		1	
Rheotanytarsus	2		1
Stempellinella	3	23	4
Stictochironomus		31	
Tanytarsus	9	6	3
Thienemanniella		1	
Tipula	-99		
Tribelos			1
EPHEMEROPTERA			
Acerpenna	1		
Baetis	127		
Caenis latipennis		19	2
Choroterpes	4	7	
Procloeon		1	
Stenacron	9	23	1
Stenonema femoratum	12	34	4
Tricorythodes	9	7	1

Aquid Invertebrate Database Bench Sheet Report

Little Lindley Cr [110983], Station #1, Sample Date: 9/20/2011 1:00:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
HEMIPTERA			
Rhagovelia		1	1
Trepobates			1
ISOPODA			
Caecidotea (Blind & Unpigmented)		1	
LIMNOPHILA			
Ancylidae		2	1
Gyraulus		5	
Menetus	1	1	5
Physella	3	8	6
LUMBRICINA			
Lumbricina	1		
LUMBRICULIDA			
Lumbriculidae			3
MESOGASTROPODA			
Elimia	4	6	29
ODONATA			
Argia	4	8	7
Basiaeschna janata			1

Aquid Invertebrate Database Bench Sheet Report

Little Lindley Cr [110983], Station #1, Sample Date: 9/20/2011 1:00:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Boyeria			1
Calopteryx			1
Enallagma			30
Hagenius brevistylus	1	3	1
Libellulidae		3	
RHYNCHOBDELLIDA			
Glossiphoniidae			1
TRICHOPTERA			
Cheumatopsyche	107		2
Chimarra	52		
Hydroptila	7	3	3
Triaenodes			12
TRICLADIDA			
Planariidae	65		3
TUBIFICIDA			
Branchiura sowerbyi		5	1
Tubificidae	1	7	10
VENEROIDA			
Pisidiidae	1	13	2

Aquid Invertebrate Database Bench Sheet Report

Little Lindley Cr [110984], Station #2, Sample Date: 9/19/2011 2:30:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina		1	1
AMPHIPODA			
Crangonyx	-99	9	22
Hyalella azteca			19
ARHYNCHOBDELLIDA			
Erpobdellidae	2		
COLEOPTERA			
Berosus		1	4
Dubiraphia		4	33
Ectopria nervosa	10	35	19
Helichus basalis			3
Psephenus herricki	74	14	2
Stenelmis	125		28
DECAPODA			
Orconectes luteus	-99	-99	-99
Orconectes virilis			-99
DIPTERA			
Ablabesmyia		12	

Aquid Invertebrate Database Bench Sheet Report

Little Lindley Cr [110984], Station #2, Sample Date: 9/19/2011 2:30:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Ceratopogoninae		1	
Chironomidae	7	1	1
Chironomus		15	
Corynoneura	5	1	1
Cricotopus bicinctus			1
Cricotopus/Orthocladius	3	6	4
Cryptochironomus		10	1
Dicrotendipes		5	8
Forcipomyiinae	2	2	1
Labrundinia	2		5
Microtendipes	2	1	
Nilotanypus	3		2
Paratanytarsus		2	13
Paratendipes		1	1
Phaenopsectra		2	
Polypedilum convictum	54		8
Polypedilum illinoense grp			2
Polypedilum scalaenum grp	2	3	1
Pseudochironomus	1	4	2
Rheotanytarsus	7	1	18

Aquid Invertebrate Database Bench Sheet Report

Little Lindley Cr [110984], Station #2, Sample Date: 9/19/2011 2:30:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Simulium	1		
Stempellinella	23	6	3
Stictochironomus		10	
Tanytarsus	13	9	12
Thienemanniella	3	2	
Thienemannimyia grp.	5	1	4
Tipula	-99		
EPHEMEROPTERA			
Acentrella	2		
Baetis	126		1
Caenis latipennis	1	11	1
Procloeon		5	3
Stenacron	37	13	
Stenonema femoratum	7	18	
Tricorythodes	1		
LIMNOPHILA			
Ancylidae	11	25	10
Helisoma			-99
Menetus		5	10
Physella	2	4	9

Aquid Invertebrate Database Bench Sheet Report

Little Lindley Cr [110984], Station #2, Sample Date: 9/19/2011 2:30:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
LUMBRICINA			
Lumbricina	1		
LUMBRICULIDA			
Lumbriculidae		3	
ODONATA			
Aeshnidae			2
Argia	13	5	10
Calopteryx			4
Enallagma		-99	50
Hagenius brevistylus	2	1	1
Hetaerina			1
TRICHOPTERA			
Cheumatopsyche	57		1
Chimarra	10		
Hydroptila	2	1	1
Oecetis		1	
Triaenodes			5
TRICLADIDA			
Planariidae	18		1
TUBIFICIDA			

Aquid Invertebrate Database Bench Sheet Report

Little Lindley Cr [110984], Station #2, Sample Date: 9/19/2011 2:30:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Branchiura sowerbyi		9	
Enchytraeidae			1
Limnodrilus hoffmeisteri	1		3
Tubificidae	9	32	26
VENEROIDA			
Pisidiidae	5		

Aquid Invertebrate Database Bench Sheet Report

Ingalls Cr [110985], Station #1, Sample Date: 9/19/2011 11:30:00 AM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina	6	1	
AMPHIPODA			
Hyalella azteca			49
ARHYNCHOBDELLIDA			
Erpobdellidae		-99	
COLEOPTERA			
Berosus	2	1	1
Dubiraphia		2	19
Ectopria nervosa	1		
Enochrus	1		
Psephenus herricki	22	1	1
Scirtidae			5
Stenelmis	30	4	2
DECAPODA			
Orconectes luteus	1	-99	
DIPTERA			
Ablabesmyia		3	1
Ceratopogoninae	4	3	

Aquid Invertebrate Database Bench Sheet Report

Ingalls Cr [110985], Station #1, Sample Date: 9/19/2011 11:30:00 AM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Chironomidae		2	
Chironomus	1	11	
Cladotanytarsus		3	
Corynoneura	1		
Cricotopus bicinctus	20		1
Cricotopus/Orthocladius	161		4
Cryptochironomus		1	
Dicrotendipes	30	32	11
Forcipomyiinae	9		1
Glyptotendipes			1
Hexatoma	4		
Labrundinia	1		2
Parametriocnemus	2		
Paratanytarsus			5
Paratendipes		1	
Pentaneura	44		
Phaenopsectra	3	1	
Polypedilum aviceps	2		
Polypedilum convictum	57		
Polypedilum illinoense grp	1		1

Aquid Invertebrate Database Bench Sheet Report

Ingalls Cr [110985], Station #1, Sample Date: 9/19/2011 11:30:00 AM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Rheotanytarsus	9		
Stempellinella		1	
Tabanus	-99		
Tanytarsus	103	19	20
Thienemanniella	23		
Thienemannimyia grp.	18		
undescribed Empididae	2		
EPHEMEROPTERA			
Acentrella	15		
Acerpenna	78		3
Anthopotamus		1	
Baetis	3		
Caenis anceps			1
Caenis latipennis	65	196	106
Choroterpes	45	25	8
Ephemera simulans		-99	
Isonychia bicolor	4		
Procloeon	3	2	2
Stenacron	1	1	5
Stenonema femoratum	10	43	13

Aquid Invertebrate Database Bench Sheet Report

Ingalls Cr [110985], Station #1, Sample Date: 9/19/2011 11:30:00 AM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Tricorythodes	1		
LIMNOPHILA			
Ancylidae	2	1	14
Menetus		2	3
Physella	4	1	3
Planorbella			3
LUMBRICINA			
Lumbricina	5	1	
LUMBRICULIDA			
Lumbriculidae	1	1	
MEGALOPTERA			
Sialis		-99	
MESOGASTROPODA			
Elimia		-99	8
ODONATA			
Argia	1		1
Basiaeschna janata			-99
Enallagma			4
Gomphidae	1		
Hagenius brevistylus			1

Aquid Invertebrate Database Bench Sheet Report

Ingalls Cr [110985], Station #1, Sample Date: 9/19/2011 11:30:00 AM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Somatochlora			-99
PLECOPTERA			
Acroneuria	-99		
Neoperla	8		
Perlinella ephyre		-99	
TRICHOPTERA			
Cheumatopsyche	2		
Hydroptila	1		
Polycentropus	1		
Triaenodes			1
TRICLADIDA			
Planariidae	6		
TUBIFICIDA			
Tubificidae	3	16	4

Aquid Invertebrate Database Bench Sheet Report

Little Lindley Cr [120021], Station #1, Sample Date: 3/19/2012 12:00:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina			1
AMPHIPODA			
Crangonyx	16	21	4
Hyalella azteca			24
ARHYNCHOBDELLIDA			
Erpobdellidae		-99	-99
COLEOPTERA			
Berosus	1	1	
Dubiraphia		4	1
Ectopria nervosa	3	6	1
Helichus basalis			2
Psephenus herricki	3	1	1
Stenelmis	93	22	9
DECAPODA			
Orconectes luteus	-99		
DIPTERA			
Ablabesmyia		21	24
Ceratopogoninae		2	

Aquid Invertebrate Database Bench Sheet Report

Little Lindley Cr [120021], Station #1, Sample Date: 3/19/2012 12:00:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Chironomidae		3	1
Chironomus		1	
Corynoneura	1	1	
Cricotopus bicinctus			1
Cricotopus/Orthocladius	39	8	6
Cryptochironomus	1	2	2
Dicrotendipes	6	93	18
Diplocladius	3		
Diptera	2	2	2
Ephydridae	1	1	
Eukiefferiella	244	43	73
Forcipomyiinae			1
Hydrobaenus	2	14	2
Labrundinia			1
Larsia	1		
Micropsectra	21	7	18
Microtendipes		1	1
Nanocladius			1
Nilotanypus	21		
Parametriocnemus	1		

Aquid Invertebrate Database Bench Sheet Report

Little Lindley Cr [120021], Station #1, Sample Date: 3/19/2012 12:00:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Paratanytarsus		1	1
Paratendipes		30	9
Phaenopsectra		2	1
Polypedilum aviceps	27		1
Polypedilum convictum	11		
Polypedilum illinoense grp	24	1	28
Polypedilum scalaenum grp	1	3	
Pseudochironomus	1		
Rheotanytarsus	2		4
Simulium	133		3
Stempellinella	9	4	2
Stenochironomus		1	
Tanytarsus	9	4	11
Thienemanniella	4	1	
Thienemannimyia grp.	15		6
EPHEMEROPTERA			
Caenis latipennis		4	
Leptophlebiidae	1		
Stenacron	4	3	
Stenonema femoratum	4	1	

Aquid Invertebrate Database Bench Sheet Report

Little Lindley Cr [120021], Station #1, Sample Date: 3/19/2012 12:00:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
GORDIOIDEA			
Gordiidae	1		
HEMIPTERA			
Belostoma			-99
Ranatra kirkaldyi			1
LIMNOPHILA			
Helisoma	-99		
Menetus	1	1	2
Physella		-99	2
LUMBRICINA			
Lumbricina	2	1	
LUMBRICULIDA			
Lumbriculidae	2	18	
MESOGASTROPODA			
Elimia	11	3	77
ODONATA			
Argia	1	-99	
Basiaeschna janata			-99
Boyeria			-99
Enallagma			8

Aquid Invertebrate Database Bench Sheet Report

Little Lindley Cr [120021], Station #1, Sample Date: 3/19/2012 12:00:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Hagenius brevistylus		1	
PLECOPTERA			
Amphinemura	1		
Chloroperlidae	1		
Isoperla	1		
Perlidae	10		
TRICHOPTERA			
Cheumatopsyche	1		
Chimarra	7		
Hydroptila	6	2	10
Triaenodes			2
TRICLADIDA			
Planariidae	55	1	4
TUBIFICIDA			
Branchiura sowerbyi		1	
Limnodrilus hoffmeisteri		1	
Tubificidae		7	1
VENEROIDA			
Corbicula	2	2	4

Aquid Invertebrate Database Bench Sheet Report

Little Lindley Cr [120022], Station #2, Sample Date: 3/19/2012 10:15:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
AMPHIPODA			
Crangonyx	5	6	17
ARHYNCHOBDELLIDA			
Erpobdellidae	3	2	-99
COLEOPTERA			
Berosus		1	2
Dubiraphia			4
Dytiscidae			1
Ectopria nervosa	14	6	5
Psephenus herricki	18	4	
Stenelmis	34	20	34
Tropisternus			1
DECAPODA			
Orconectes luteus	-99		-99
DIPTERA			
Ablabesmyia	1	3	3
Ceratopogoninae		2	1
Chironomidae	1		3
Clinocera	1		

Aquid Invertebrate Database Bench Sheet Report

Little Lindley Cr [120022], Station #2, Sample Date: 3/19/2012 10:15:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Cricotopus bicinctus	2		
Cricotopus/Orthocladius	175	57	94
Cryptochironomus	3	4	
Dicrotendipes	27	153	220
Eukiefferiella	103	14	26
Hydrobaenus	1	4	
Micropsectra	2	3	6
Microtendipes	13	2	
Nilotanypus	3		
Parametriocnemus			1
Paratanytarsus		1	4
Phaenopsectra		2	4
Polypedilum aviceps			5
Polypedilum convictum	75	1	14
Polypedilum illinoense grp			4
Polypedilum scalaenum grp	9	7	2
Pseudochironomus	5	3	
Rheotanytarsus	18	4	23
Simulium	29		2
Stempellinella	2	2	2

Aquid Invertebrate Database Bench Sheet Report

Little Lindley Cr [120022], Station #2, Sample Date: 3/19/2012 10:15:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Stictochironomus		1	
Tanytarsus	19	15	22
Thienemanniella	10		3
Thienemannimyia grp.	36	6	12
Tipula	-99	-99	-99
EPHEMEROPTERA			
Stenacron	11		
Stenonema femoratum	2	-99	3
GORDIOIDEA			
Gordiidae	-99		
HEMIPTERA			
Gerris	1		
LIMNOPHILA			
Ancylidae	6	3	2
Helisoma		-99	-99
Menetus		2	4
Physella	1	3	4
LUMBRICINA			
Lumbricina		-99	
LUMBRICULIDA			

Aquid Invertebrate Database Bench Sheet Report

Little Lindley Cr [120022], Station #2, Sample Date: 3/19/2012 10:15:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Lumbriculidae	1	5	
ODONATA			
Argia	1		1
Calopteryx			2
Enallagma			3
PLECOPTERA			
Perlesta	2		
TRICHOPTERA			
Cheumatopsyche	9		
Hydroptila	10		2
Ironoquia		-99	-99
Rhyacophila			1
Triaenodes			3
TRICLADIDA			
Planariidae	10		
TUBIFICIDA			
Branchiura sowerbyi		1	
Limnodrilus claparedianus			1
Limnodrilus hoffmeisteri			5
Tubificidae	12	7	8

Aquid Invertebrate Database Bench Sheet Report

Ingalls Cr [120023], Station #1, Sample Date: 3/19/2012 1:50:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina	1	9	2
AMPHIPODA			
Hyalella azteca		-99	20
COLEOPTERA			
Agabus		1	-99
Dubiraphia			3
Dytiscidae		3	2
Peltodytes		1	
Psephenus herricki	4	2	3
Stenelmis	32	4	2
DECAPODA			
Orconectes luteus	1		
Orconectes virilis		-99	1
DIPTERA			
Ablabesmyia		19	10
Ceratopogoninae	4	6	1
Chironomidae	8	11	5
Chrysops	-99		

Aquid Invertebrate Database Bench Sheet Report

Ingalls Cr [120023], Station #1, Sample Date: 3/19/2012 1:50:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Corynoneura	4	2	9
Cricotopus/Orthocladius	29	31	19
Dicrotendipes		3	4
Diptera		2	
Eukiefferiella	25	13	16
Hexatoma	-99	2	
Hydrobaenus	1	39	5
Labrundinia			18
Limnophila	2		
Micropsectra	1		
Nanocladius			1
Nilotanypus	4		
Parakiefferiella		1	1
Parametriocnemus	3	2	
Paratanytarsus		1	7
Paratendipes	13	8	
Phaenopsectra			2
Polypedilum aviceps	13		
Polypedilum convictum	16	1	1
Polypedilum illinoense grp	1	1	2

Aquid Invertebrate Database Bench Sheet Report

Ingalls Cr [120023], Station #1, Sample Date: 3/19/2012 1:50:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Polypedilum scalaenum grp		3	
Prosimulium	1		
Pseudosmittia			1
Rheocricotopus	7		
Rheotanytarsus	1		2
Simulium	23		
Stempellinella	2	5	1
Stictochironomus		1	
Sympotthastia	14	3	6
Tanytarsus	11	20	7
Thienemanniella	40	6	11
Thienemannimyia grp.	32	28	6
Tipula	-99	-99	
Zavrelimyia	1	2	
EPHEMEROPTERA			
Acentrella	346	2	24
Acerpenna	15	1	2
Caenis latipennis	21	74	63
Callibaetis		-99	7
Heptageniidae	31		

Aquid Invertebrate Database Bench Sheet Report

Ingalls Cr [120023], Station #1, Sample Date: 3/19/2012 1:50:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Isonychia bicolor	1		
Leptophlebia	3	3	1
Stenacron	19	18	
Stenonema femoratum	2	10	11
LIMNOPHILA			
Ancylidae			3
Helisoma			-99
Physella	1	1	2
Planorbella			1
LUMBRICINA			
Lumbricina	3	-99	
LUMBRICULIDA			
Lumbriculidae	3	2	
MESOGASTROPODA			
Elimia	-99		3
ODONATA			
Aeshnidae		1	
Argia		1	
Basiaeschna janata			2
Calopteryx			-99

Aquid Invertebrate Database Bench Sheet Report

Ingalls Cr [120023], Station #1, Sample Date: 3/19/2012 1:50:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Dromogomphus			1
Enallagma			4
Somatochlora		-99	-99
PLECOPTERA			
Acroneuria		-99	
Allocapnia	1	-99	
Amphinemura	26		2
Chloroperlidae	14	-99	
Isoperla	58	2	1
Leuctridae	4		
Neoperla		-99	
Perlesta	43	4	7
Perlinella drymo		-99	
RHYNCHOBDELLIDA			
Glossiphoniidae		-99	
TRICHOPTERA			
Hydroptila	4		4
Ochrotrichia	5	3	
Polycentropus		-99	
Pycnopsyche			-99

Aquid Invertebrate Database Bench Sheet Report

Ingalls Cr [120023], Station #1, Sample Date: 3/19/2012 1:50:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Rhyacophila	5		
Triaenodes		1	2
Wormaldia	1		
TRICLADIDA			
Planariidae	6	1	
TUBIFICIDA			
Limnodrilus hoffmeisteri		1	1
Tubificidae		1	1